SELECTIONS

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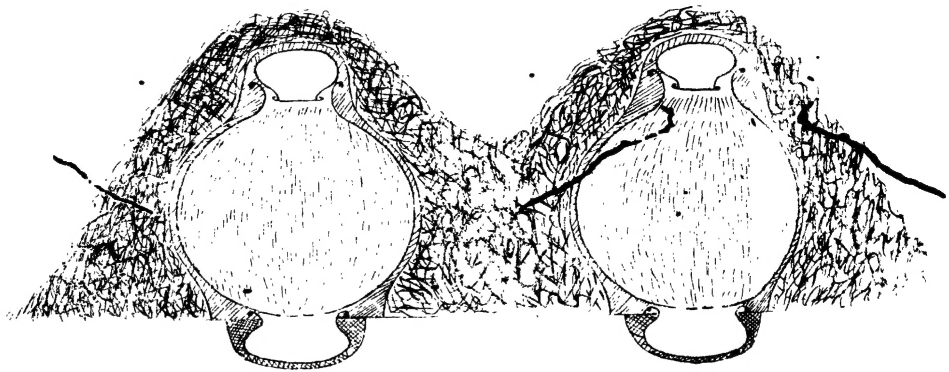
Section through

2 Pots

ready for Firing

Surface of ground



Lithd by Josh Barthelemy I. C Press

No. XXII.

MEMORANDUM ON THE MANUFACTURE OF TAR.

By J. D. Smyth, *Esq.*, *Assistant Civil Engineer.*

In manufacturing the Tar, I adopted the native mode, which, I believe, is well understood; but to make it understood by those who have never seen the process, I will explain it:—

A large earthen vessel, about twelve seers, having three small holes drilled in the under side, is filled with the scraps of wood; on the top is placed another smaller one, which will admit of going about one-third into the mouth of the large vessel. These are then well luted with a stiff mud at the joint, and likewise a thin coating, about 5 inches thick, is put all over them, except near the bottom. These vessels thus prepared are then set on the top of a small one, about four seers, with a large mouth previously sunk even with the ground; the joint or seat is made tight with mud put round rather thick. This coating and lute at the joints should then be allowed to set a little; the still, which it may be called, is now ready for working; the whole above ground, being the large vessel with its top, should be completely covered with fuel and the fire lighted.

It will take from four to eight hours, according to the fire, to extract all the Tar from the wood; after it has been allowed

to cool a little, the ashes of the fire should be raked away until the under vessel or receiver, is visible, and with a thick cloth in the hands the large pot can be lifted off.

Great care should be observed in lifting the pot, to prevent any of the lute round the joint and ashes from the fire, falling into the lower vessel, which contains the Tar; this vessel can now be lifted and the tar-taken away; the large pot should be opened, and the charcoal, which is in it, taken out; the vessels are then ready for charging and working as at first.

If care is taken in handling the pots, the coating of mud, which was originally given them, need not be disturbed or much broken; this will be an advantage, as each time a vessel requires a new coating, a considerable quantity of more fuel will be expended to produce the Tar and without this coating of mud, the large vessel will not last more than two firings; in fact they stand every chance of being cracked or broken with the first. Upon handling the pots carefully, and paying attention to the coating of them, depends the economical working of the Tar manufactory; each time a new pot is set going, the produce of the first firing is absorbed by the vessel, as well as an additional quantity of fuel consumed to heat it through. I have fired one pot as many as twelve times before it broke. I used the common vessels purchased in the bazaar. The pots should be placed in a row with about one-and-a-half foot space between each; when worked in this way, there is a great saving of fuel.

I was induced to try the making of Tar to clear my timber-yard of chips, which I could not otherwise dispose of, and which accumulate rapidly when much timber is cut up.

I picked the first chips for charging the pots, about two fingers in size, and used the remainder for firing.

The following is the cost of working a set of ten pots fired once a day :—

Two men, at three anas per diem,....	0	6	0
Four men, at two anas ditto,......	0	8	0
Average cost of pots, each firing,.......	0	0	4
	0	14	4
Deduct value of 22 seers of charcoal, at 8 anas per maund,.	0	4	0
Total,......	0	10	4

Produce 13 seers 6 chitaks of Tar, 9.27 pie, or say 10 pie per seer.

The average produce I have found to be as follows :—

One seer of wood yields 2.6 chitaks of tar, and 4.3 chitaks of charcoal, giving 6 seers 9 chitaks as the produce of each seer of wood put into the pot, or 43.1 chitak per cent. To procure a seer of Tar requires 6 seers 4 chitaks of fresh scraps for charging a pot, and 2 maunds 6 seers and 9 chitaks of scraps for fuel.

The Tar thickens much by exposure to the atmosphere, and forms an excellent preservative for wood works.

(Signed) J. D. SMYTHE, *A. C. Engr.*,
Executive Officer, Workshops,
Baree Doab Canal.

No. XXIII.

REPORT ON THE GEOLOGICAL STRUCTURE AND MINERAL WEALTH OF THE SALT RANGE IN THE PUNJAB; WITH MAPS, SECTIONS, &c.

By ANDREW FLEMING, M. D. *Edin.; Assistant Surgeon, 4th Regt. Punjab Cavalry, in charge of the Geological Survey of the Salt Range in the Punjab, Season* 1851-52.

PRELIMINARY REMARKS.

In compliance with the instructions received at Muree on the Indus, on the 14th February, 1851, from the Most Noble the Governor General, I have endeavoured to make such an examination of the Salt Range as will enable His Lordship in Council to judge as to the exact character of its mineral wealth.

The results of this examination have been embodied in the accompanying Report.

From unavoidable circumstances, I was unable to commence the regular survey of the Range, until the end of February 1851, and owing to the heat was obliged to cease work in the middle of April.

On the 1st November, 1851, the survey was again renewed, and the sanction of Government having been obtained for the construction of a Sketch map of the Salt Range (the want of which to guide us in our survey has been severely felt), M. William Purdon, (1st Assistant), aided by Mr. William Theo-

bald (2nd Assistant), was directed to devote his attention to its construction. The map herewith submitted is the result of their labours during the cold weather of 1851-52, to the end of which period the duration of the survey was limited.

The map is, I believe, the first which has ever been made of the Salt Range from a regular survey, and for its accuracy, Mr. Purdon is alone responsible. I trust it will supply a want in all maps of the Punjab hitherto published, in none of which, that I have seen, is even the general direction of the Range correctly laid down.

The geological examination of the Range has been executed entirely by myself, and in addition to that of the Salt Range proper, a rapid survey was made of its continuation in the range of hills which runs down the west bank of the Indus from Kalabag to Kafir Kote. I thus have been able to add considerably to our previous knowledge of the geology of the Punjab. A most interesting mass of hills, called Korana, which rises abruptly from the plain of the Jech Doab, has also been examined.

During the course of my labours, I executed a rough military survey, with a hand prismatic compass, of the district passed over, from which I have constructed, for my own guidance, a rough sketch map. This I have had copied and coloured geologically, by a Mr. Blaney, an Eurasian draftsman, and herewith submit it as illustrative of my report.

The report itself will be found, in many parts, to be a repetition of the reports on the Salt Range I made to Government in 1848. These were drawn up after a very rapid inspection of the Range between Baganwala and Kalabag, in the month of April, a period of the year, when it is next to impossible to examine, satisfactorily, such hot and barren hills.

In the present report I have corrected several errors, the result of a too cursory examination of the strata, and have added, very considerably, to the matter of my previous reports.

I regret that I am unable to announce the occurrence, in the Salt Range, of much mineral wealth, of the existence of which Government have not already been made aware.

The nature of the formations precludes the likelihood of any valuable metallic ores (we except those of iron) being found. The nature and character of the Coal deposits have been fully described; but, for reasons stated, we fear they will turn out of but little practical value.

In a scientific point of view, however, I would fain hope that much has been recorded, which, to Geologists, will prove highly interesting.

As I was ordered to resume my medical duties at the close of my field work, it was necessary that the sections which accompany the report should be prepared, before I separated from my Assistants, who were directed to remain at Pind Dadun Khan.

These were hurriedly drawn in camp by Mr. Theobald, from rough sketches made by myself in the field, and must be considered rather as sketches than true sections, which, without the necessary data at the time, as to heights and distances, it was impossible to have constructed.

The table of heights calculated from barometric and thermometric observations will, I trust, prove interesting as well as useful. I need hardly remark that they can be considered as rough approximations.

A complete collection, for submission to Government, of the rocks, minerals, and fossils collected during my survey, has

been prepared, and, in compliance with Government orders, collections, illustrative of the mineral wealth of the Salt Range, have also been made for the Museums of the Asiatic Societies of Bengal and Bombay, and of the Agra College.

The preparation of my report, and the examination and arrangement of my specimens, have occupied entirely my leisure hours during the past hot season. I am aware that numerous imperfections are to be found in it, but in judging of its merits, or demerits, I trust it may be borne in mind, that I have been in a position where books of reference, or collections for comparison, are quite inaccessible, and have consequently been entirely dependent on my own resources.

(Signed) A. FLEMING, M. D.

Jelum, Punjab, Sept. 12th, 1852.

On the General Physical features of the Salt Range in the Punjab.

The hills, generally included under the designation of the Punjab Salt Range, occur in the northern part of the Sind Sagur Doab, or district between the rivers Jelum and Indus, crossing it from E. to W. between the parallels of 32° 22′, and 33° N. Latitude, and 71° 30 and 73° 30′ E. Longitude.

The Salt Range may be considered as resulting from the union of three low independent ranges, subordinate to the Punjal branch of the Himalayas, which run towards the plain in a southerly direction.

The first, or most easterly, of these ranges runs along the left bank of the river Jelum, and opposite the town on the line

of the trunk road, receives the name of the Kharian Range. Further down the river this is known as the Pubee Hills; and near Rusool, famous for the position of the Sikh encampment, after the battle of Chilianwala, approaches the river, being evidently continuous with hills of similar character, which form its right bank between Darapoor and Jelalpoor, and which are locally designated Surafur.

The central, or Rhotas, range crosses the Peshawur road about 7 miles West of Jelum, and stretches in a S. W. direction as far as the Boona nula. Here it takes a southerly turn, and under the name of Chumba runs on to Jelalpoor, uniting in its course with the Kharian Range. The well known mountain Tila, 18 miles S. W. of Jelum, is the highest point of this range, and not less than 3,000 feet above the level of the sea.

The western, or Bakrala, Range is separated from that of Rhotas, by a raviny country about 10 miles in breadth. It runs parallel with the latter, and after crossing the Boona nula at the Margula Pass, forms the ridge known as Diljuba, the west end of which unites with the general mass of hills forming the Salt Range.

By the union of the Kharian and Rhotas or Chumbul ranges at Jelalpoor, a ridge is formed, presenting a steep escarpment to the south, and a highly inclined slope to the north; at this point it is about three miles distant from the Jelum, an alluvial plain intervening, the height of which does not probably much exceed 600 feet above the sea, and which, as we proceed westward, gradually expands into the plain of the Sind Sagur Doab.

From Jelalpoor the direction of the range is about, west by south, as far Kutha. Here it takes a turn to the S. W., running in this direction as far as Jubee, which is its most southerly

point. From this, for a distance of about six miles, it runs nearly due west to Choos, and then gradually trends round to the north, running from Futeepoor to the Indus in a N. W. direction. It maintains the same course for about four miles on the west bank of the Indus, beyond which it gradually expands into the mass of hills, that stretch north between Bunoo and Kohat, and are known as the Chountra Hills. The south-western portion of these, along the west bank of the Indus, are elevated into a high ridge, presenting a steep escarpment to the east, evidently continuous with that of the Salt Range, and joining it near the village of Kooch, four miles N. W. of Kalabag, at nearly a right angle. This ridge, known as the Chichalee Range, runs in a direction S. S. W. towards the Koorum river, beyond which it may be said to be continuous with that of Kafir Kote, forming the right bank of the Indus for several miles below the village of Bahadur Dok, and which is apparently a branch from the great Sooleeman Range, which runs parallel with the Indus in the Derajat and Sind, and forms the natural western boundary of our Indian Empire.

In order to convey, if possible, an idea of the general features of the Salt Range, we shall follow its three natural divisions, into a southern or salt, a central or cultivated limestone, and a northern or sandstone district, beginning from Jelalpoor where the Salt Range proper may, for practical purposes, be considered to commence.

Along its southern limits, the Range presents a most jagged angular outline, produced by a succession of points running towards the plain and separated by deep intervening strata. These points are covered by, and in many places formed of, masses of rock and debris, which during the upheaval of the Salt Range, and subsequently from atmospheric and disturbing agencies, have been detached from a high escarpment with the strata of which they have undoubtedly been at one time continuous.

This escarpment, extending from Jelalpoor to the Indus, is most prominently marked in the eastern part of the Range. Its continuity is frequently broken by deep transverse gorges, running parallel to the general line of dip of the rocks, through which the greater number of the streams which, drain the Salt Range, escape into the plains. None of these, except during heavy falls of rain, reach either the Jelum or the Indus, but are absorbed by the thirsty, sun-baked, alluvial soil, which instead of fertilizing, they convert into a comparative desert by the deposition of saline matter, acquired in their course over the salt rocks which are chiefly confined to the southern district of the Range.

To this rule the streams escaping from the hills at Baganwala, Kutha and Moosakhel,' are exceptions. The two former, though slightly saline, are entirely consumed for agricultural purposes. The latter, known as the Valice River, runs entirely through strata superior to the Salt rocks, and pours out a considerable volume of sweet water, a very small portion of which is employed for irrigation, the greater part being allowed to run to waste. By the judicious formation of an aqueduct (stone and lime are available in abundance on the spot) with sluices for the withdrawal of the water, means for the irrigation of a very considerable extent of now unproductive soil, could be rendered available. The various streams we have alluded to, after heavy rains, become suddenly swollen, and, acquiring the characteristic impetuosity of mountain-torrents, bear along with them an immense quantity of boulders, gravel and mud, which are, along the foot of the hills, deposited in a succession of zones extending for two or three miles.

As may be supposed, a district formed in this way presents a somewhat barren aspect, and with the exception of a scanty rain crop of Bajra,* Joar† and annual cotton, there is but little

* PANICUM *spicatum*. † HOLCUS *Sorghum*.

ground under cultivation. In the cold weather, after heavy rain, it assumes a somewhat green aspect, but when rain does not fall, as was the case in the cold weather of 1851-52, hardly a blade of grass is to be seen : and much do the villagers suffer for want of water, they being, in a great degree, dependent for the supply of this necessary on seasonable falls of rain, which they collect in kucha (mud) tanks, resorted to, as long as a supply of water lasts, indiscriminately, by men and cattle.

A stunted jungle of CAPPARIS *aphylla* (kureel,) SALVADORA *persica* (peeloo,) ZIZYPHUS (beir,) ACACIA *modesta* (phoolahee,) and PROSOPIS *spicigera* (jund,) occurs along the foot of the hills, and affords grazing to numerous camels, sheep and goats, as well as an abundant supply of fuel to the villagers. These shrubs appear to thrive best in soil charged with saline matter, and form the mass of jungle in the uncultivated tracts of the Punjab Doabs which generally present on their surface a white saline efferves-cence, known under the name of kulur, and which is a mixture of salt and sulphate, with generally a trace of carbonate of soda. As we ascend the alluvial zones along the foot of the hills, vegetation gradually diminishes, and on the Salt rocks, which are the lowest in the series, it seems to reach a minimum. A few stunted kureel, peeloo and phoolahee, bushes may be observed, but succulent salsolas* and other chenopodiacious plants known to the natives under the general term "java," with one or two interesting Cruciferæ characterize these, and abound in the Salt-marl. Above the Salt rocks vegetation again increases, but on account of the want of water along the foot of the escarp-ment of the Range, is every where scanty.

On reaching the summit of the escarpment which is formed of limestone rocks elevated into a ridge varying from 2 to 5,000 feet in height, we are introduced to a district of a totally differ-ent aspect from that to the south, presenting at first, generally, a

* These, in the plain along the foot of he Range, are, after the rains, cut, col-lected into heaps and burnt for the sake of their ashes, which are called sujji-mutee, a coarse kind of carbonate of soda.

considerable slope to the N., which is succeeded by a series of horizontal ridges with intervening valleys.

Between Jelalpoor and Baganwala, the Range presents merely a ridge; but beyond the latter place this expands into a kind of table-land two or three miles in breadth, extending from the escarpment between Baganwala and Jutana N., to the foot of mount Drengan, the highest but one of the Salt Range hills which rises from it behind the village of Bisharut. This table-land is about 2,800 feet above the level of the sea, and, though entirely dependent on rain, is all under cultivation, and yields, generally, fair crops of wheat, barley, &c. It extends in a S. W. direction for about a couple of miles, and then becomes broken up by limestone ridges, into a succession of small cultivated valleys, one of which runs along the S. side of mount Kuringulee under the village of Vuhali.

Proceeding westward to Kutas, we enter the district of Kahun, which is made up of a succession of ridges and cultivated valleys about 2,000 feet above the sea-level. At the west end of this district is the Salt Lake of Kulur Kahar (Kulur in Sanscrit means salt, Kahar, Sansc., a lake). Its extent varies much in different seasons, but may be stated as about a mile long by half a mile broad, its greatest length being from east to west. It receives the drainage from the various hills around, and also a small stream of fresh water which enters it at its West end near the village of Kahar. Its depth no where exceeds three or four feet, and its margin is formed of black fetid mud, outside which is a thick saline incrustation, produced by the evaporation of its water. Its saline ingredients seem derived from salt springs, which issue from a mass of marl at its S. W. end. Its water is a strong brine, but owing to the constant drainage into it, after rains, of fresh water, it never reaches a point of concentration sufficient to admit of salt being deposited in the bottom of the lake. After any heavy rains, and when its surface-level is considerably raised, a portion of its water finds

an exit by a nula at its N. W. corner, which joins a small stream called Nurwa in the hills to the north. This periodical overflow also assists in preventing the concentration of the water. It appears to contain no fish, but it is a favourite resort of ducks and other water-fowls.

Beyond Kahar on to Pyle, the district becomes more hilly, and only occasional patches of cultivation are to be seen. Here the Range, which to the eastward does not exceed ten or twelve miles in breadth, becomes narrow; but soon rapidly expands into a mass of hills which, at their broadest point, North of Jubee, is probably not less than eighteen miles.

Among these are several cultivated valleys, the principal of which are those of Khubukee and Sone Sikesur. The former presents nothing remarkable, except that after heavy rain, one or two small lakes form in its lower parts.

The Sone Sikesur valley is about twelve miles long, and three broad, and is inclosed between two ridges of limestone hills. It is for the most part under rich cultivation, and in the hot weather has the reputation of being as cool as Kashmeer. At its west end is a great salt lake called "Sumundur," three miles long, by one and a half broad, and beyond it mount Sikesur, the highest point of the Salt Range, attains an elevation of about 5,000 feet above the sea-level. Here the central district of the Range may be said to end, its summit forming a ridge on to the Indus.

The Salt Lake or Sumundur (sea) is in every way similar to the one of Kulur Kahar, but as far as we are aware, receives no permanent streams. During rain, the drainage into it from the Gumundra, Puteeal and Kurung ridges, which surround it, must be very considerable, and the boulders in several nulas which enter its eastern extremity, mark the force of the floods which it

at times receives. There appears no exit for the waters of the lake, which by solar evaporation must be kept within due bounds. All the hills by which it is surrounded are composed of limestone, and hence it is probable that salt springs enter it from below. Its water is a strong brine, and a thick saline incrustation covers

South of the salt lake, in the hills between Kufree and Vurcha, and about four miles from the former, is a fresh-water lake of considerable depth, called Julhur Kahar (Julhur, Sanscrit, a spring of fresh water,) about three quarters of a mile long, by about half-a-mile broad. It is most picturesquely situated at the foot of a limestone escarpment, and receives the drainage of the limestone hills around, and of the small valley at the west end of which it is placed. We believe we were the first European who had ever visited it, and were not aware of its existence till we stumbled upon it accidentally. The pleasure of beholding such a sheet of fresh water cannot be appreciated, to its full extent, but in the midst of hills like the Salt Range, where fresh water is no where abundant, and clean water is a scarce luxury.

The vegetation in the central and northern districts of the Range presents a striking difference to that on its south side, but though the hills attain to a considerable height, there is nothing to indicate an approach to an Alpine flora. The want of any of the ordinary trees characteristic of the Sub-Himalayan ranges of elevations from two to five thousand feet, is very remarkable, and with the exception of a few stunted HYPERANTHERA and Semul trees (BOMBAX *Heptaphyllum*,) whose large scarlet flowers appear in the months of February and March, nothing deserving the name of a tree is to be seen on the Salt Range from the Jelum to the Indus. This we conceive is to be attributed entirely to the general absence of soil on the surface of the limestone rock of the district, the debris of which seems all to be washed into the valleys, where it forms a productive soil. But although

trees are deficient, the hills of the central district present a green and refreshing aspect, being generally covered with a low bush jungle, formed in great part of DODONÆA *Burmanniana* (Sunhetta,) and ADHATODA *vassica* (Behikur.) These two shrubs, but particularly the former, may be considered as peculiarly characteristic of the central district, their fibrous roots penetrating deeply into the soil between the rents and fissures which every where traverse the limestone strata. Mixed with these may be observed the Phoolahee and the Kow—a species of OLEA* famous for its long and straight sticks which make excellent hammer or hatchet handles.

After rain a good deal of grass springs up, forming tufts along the fissures in the limestone; and a, by no means inconsiderable, number of the smaller flowering plants may also be collected during the months of March, April and May.

The northern district of the Range is formed of a succession of ridges of soft sandstones and clays separated by deep ravines. These present an escarpment to the south, and dip to the north at a high angle under the plain of Potowar, the general name for the country north of the Salt Range, and which in its neighbourhood does not probably exceed 1,000 feet above the level of the sea. They are of small breadth in its eastern and central parts, but towards the Indus, expand into barren hills that extend from Maree to Mokhud, a distance of fully 16 miles.

This district presents scarcely any cultivation, and its natural vegetation is much the same as that of the central district, though less abundant. The GRISLEA *tomentosa* (Tawa) is the only shrub we have observed to be confined to the soft sandstone ridges.

In the Salt Range all goods, &c. must be conveyed on camels, mules, or bullocks; paths, passable for loaded camels,

* Probably O. *Europæa*.

cross it at Dundhote, Mukrach, Surdee, Nurpur, Kutha and Numul. The best of these are the Dundhote, Kutha and Numul ones. The traffic over them is, however, small, and chiefly confined to salt. The grain grown in the Salt Range is, we believe, not more than sufficient to supply the wants of its population, which is chiefly Mahomedan.

On the Geological Structure of the Salt Range in the Punjab.

All the rocks forming the Salt Range appear to belong to the strata termed fossiliferous, by Sir Charles Lyell, whose classification will be followed throughout the present Report.

We recognize then the following formations in an ascending order, and under each of these, shall endeavour shortly to describe their various characteristic sub-divisions, noticing, as we proceed, the minerals, &c. which they yield :—

1	Primary or Palæozoic.	Devonian.	*a.* Red marl with gypsum and rock salt. *b.* Lower red sandstone and grit, with conglomerate. *c.* Greenish micaceous sandstones and shales with grey dolomitic (magnesian) sandstone. *d.* Upper red variegated sandstones, grits, conglomerates and clays.
		Carboniferous.	*a* Lower limestone, calcareous sandstone and shales. *b.* Grey sandstone and shales. *c.* Upper limestone, sometimes magnesian.
2	Secondary.	Oolitic.	*a.* Yellow iron-stained quartzose sandstones, grits and bituminous shales. *b.* Cherty thin-beded limestones with shales. *c.* Green Belemnite sandstone and shales.

3	Tertiary.	Eocene.	Brown calcareous sandstone, nummulite limestone, marls and alum shales with lignite.
		Miocene ?	Greenish sandstones argillaceous grits, conglomerates, and red and green clays.
4	Post Tertiary.	Recent.	Alluvium..

Primary, fossiliferous Devonian Rocks.

a. Red marl with gypsum and rock salt. This rock gives to the Salt Range one of its most characteristic features, appearing generally at the foot of its southern escarpment, and in the bottoms of the various deep ravines which intersect the hills.

The marl occurs as the lowest rock, being subordinate to a red sandstone into which it seems to pass, the transition being marked by dark coloured fissile argillaceous beds. At Jutana and in the Chukee Wan near Jubee, a coarse red sandstone with bands of conglomerate, is seen in some places, cropping out under the marl, but as great disturbance occurs among the strata at these localities, and as the sandstone is identical in mineral character with that which, in the regular order of things, appears above the marl, we are disposed to consider its occurrence under it in the localities above mentioned, as the result of an overturn.

The marl can be recognized, at a distance, by its most singular brick-red colour, totally different from that of any ordinary clay, which immediately impresses one with the idea, that it has been subjected to igneous agency.

It does not disintegrate when treated with hydrochloric acid, but in powder effervesces strongly, the greater part remaining undissolved, in the shape of a red mud composed of clay and sul-

phate of lime or gypsum. The portion soluble in acid, consists of carbonate of lime and carbonate of magnesia, in about equal proportions, with a little alumina and peroxide of iron, to which latter substance the marl owes its colour. The rock is therefore a clay, cemented by gypsum and the carbonate of lime and magnesia into the consistency of stone, the gypsum predominating and frequently appearing in laminæ of selenite in the marl, which sometimes presents a radiated aspect, from a peculiar crystallization of the sulphate of lime.

In many places it is traversed by veins of gypsum, which seems to have been formed in rents in the marl, and give it a most singular honey-combed appearance. These veins often traverse the included irregular beds of gypsum, proving they are more recent than those, though in mineral character the gypsum of both the veins and beds is identical. In several localities thin beds of chert and coarse silicious sinter, containing patches of chalcedony, may be observed.

The marl is extremely tough, and on this account, though by no means hard, the work of sinking shafts or galleries in it, is very laborious. It forms hills, some of which rise to the height of 1,500 feet above the sea, of a most jagged appearance, which is in a great measure produced by the heavy falls of rain, dissolving out the gypsum and its earthly carbonates, and forming in it deep ravines and channels. These, by undermining the marl, frequently produce extensive slips, which cause serious annoyance in the working of the salt.

On tracing up some of the ravines, where the marl is well developed, it seems to form the centre of an anticlinal axis, the rocks superior to it (*see* Table No. 7) dipping away from either side of its out crop at a considerable angle. At the end of some of the gorges, it often presents an amphitheatre of small hills surrounded by scarped precipices of the superior rocks. This

may be well seen at the upper part of the Nilawan ravine below Noorpoor, and in the Seral Ravine at Surdee, in both of which localities it has a remarkably cruptive aspect.

In the eastern part of the Range, the marl presents scarcely any traces of stratification. Towards the Indus, however, in the neighbourhood of Choor, Vurcha, and Futeepur, where it is extensively developed, thin beds of archillaceous dark red sandstone occur in the marl, and indicate its being a stratified deposit.

At several places, but particularly around Pind Dadun Khan, the marl, for some depth from the surface, has much the character of a breccia; angular masses of salt, gypsum, sandstone and limestone, similar to those occurring in situ, being diffused through it. As the numbers of the fragments appear to decrease the further from the surface we examine the breccia, and as they are most numerous where there is evidence of the greatest disturbance in the surrounding rocks, it is most probable that the breccia marl, which we have seen in some ravines fully 200 feet thick, has been formed on the surface of the regular marl at the time of, or subsequent to, the upheaval of the Range to be hereafter noticed. Indeed its formation may be observed after every heavy fall of rain, which washes large quantities of red mud and fragments of rock into hollows in the marl, which ultimately become cemented by the infiltration of sulphate and bicarbonate of lime, held in solution by the rain-water, and derived from the strata over which it passes in its downward course.

We have hinted that the marl in some places has a singularly eruptive appearance, but the distinct proofs of stratification which it presents in the western part of the Range negatives the idea. It is probable, however, that it has undergone metamorphism from igneous influence, the exact nature of which it is dif-

ficult to ascertain. In no one locality in the Salt Range is there any evidence of the existence of plutonic or volcanic rocks, by which this metamorphism could be effected, or the great disturbance produced, which is apparent every where. In addition to the brick-red colour of the marl, which at once associates itself with the aspect of a well-burnt brick-kiln, the contained gypsum in many places and particularly on its surface, is converted into a powder-like plaster of Paris, which can only be prepared artificially by baking gypsum. This appearance is most common towards the upper parts of the marl, on which at Keura, Mukrach, and Noorpoor, patches of a most singular chocolate-coloured argillaceous rock of a somewhat trappean aspect occur, just at the point where the marl passes by fissile argillaceous beds into the red sandstone. It every where appears broken up into small masses, which sometimes present a scoriaceous aspect, and include a curious radiated mineral not unlike some varieties of Tremolite, nodules of green clay, and nests of talc. The patches of this rock are quite superficial, and do not extend beyond twenty or thirty feet, except in the gorge above the Keura village, where it seems to form a bed about 1½ feet thick, which may be traced on the West side of the gorge for about 80 yards, when it thins out, passing apparently into argillaceous sandstone, a metamorphosed portion of which it appears to be.

It effervesces slightly with muriatic acid, which dissolves a little peroxide of iron, alumina and carbonate of lime with a trace of magnesia.

In addition to the above indications of the marl having been subjected to a high temperature, we would add the fact that the fissile sandstones resting on the marl are every where rent and shivered into small fragments, which appearance gradually vanishes as we leave the marl. The beds of chert and sinter before noticed as occurring in it, could only have been deposited by the marl waters, silicia being only soluble in water (generally alkaline) at a high temperature and under high pressure.

Minerals.

The only two minerals of importance which the red marl yields, are rock salt and gypsum. These we shall notice in detail.

Rock Salt.

This valuable mineral, the origin of which is so veiled in obscurity, occurs in the marl apparently in a bed from 150 to 200 feet thick, towards its upper surface, but, wherever salt occurs, masses of it of all sizes, which have been detached from the original bed, are found scattered through the marl at various depths.

Three varieties of salt occur, the red, the white, and the transparent or glass salt. The former is obtained in greatest quantity, and being tougher and more difficult to reduce to powder than the other two varieties, stands transportation better, and is consequently in greatest demand among the salt merchants.

The mineral, in all its varieties, is a nearly pure chloride of sodium, the only foreign soluble ingredient it contains being a trace of sulphate of lime. Except when the salt is mixed with marl, it contains no chloride of magnesium, an impurity which generally occurs in rock salt, and the absence of which in that of the Salt Range, renders it but slightly deliquescent. The colour of the red salt is not, as might be supposed, derived from a salt of iron or manganese, but is probably of an organic nature.

The salt has every appearance of having been formed by crystallization from a brine solution, in which as much marl as mud has at times been mechanically suspended. At the lower and upper limits of the bed, where the deposition of the salt has commenced and ended, it is much mixed with marl, but in its interior this merely forms thin partings in the pure salt, which mark its

stratification. As the salt presents more of a crystalline aspect in the interior of the bed, than at either its upper or under surface we are inclined to think that it has been there formed during a very slow evaporation of the brine solution, which from the absence of mud, must have been in a state of great quiescence. The salt is every where solid, and never presents cavities lined with crystals of salt, which we would expect to find, had it been a sublimed product.

The salt bed bears evidence of having been exposed to violent disturbing agency, as it can never be traced for any distance in the interior of the veins, without observing frequent fractures in it, or partial faults, which are generally filled with coarsely-powdered salt, gypsum and marl, produced, probably, by the fractured ends of the bed rubbing against each other during the process of upheaval, or from subterranean movements subsequent to this.

The mineral has hitherto been mined in a most primitive manner, no alterations or improvements having been introduced, since the annexation of the Punjab in 1849.

When a spot has been fixed upon, as a promising locality, a tunnel is cut in the marl about five feet high and three and half feet broad, and carried on until salt is reached, the proximity of which is generally indicated, by the marl becoming moist and assuming more the character of a dark red clay. The mineral is then excavated as long as a supply is procurable, no attention being paid to leaving pillars, at intervals, for the support of the workings, the consequence of which is that great annoyance is experienced from the falling in of the roof of the mines; and accidents to the unfortunate miners themselves are of frequent occurrence. Should the shaft have been sunk on, and reached only a mass of salt, after this is worked out, the mine is either abandoned, or a galler driven to a greater depth into the marl

until another large mass is found or the salt bed reached. As this invariably has a strike and dip corresponding to the strata superior to the marl, the stratification of the salt guides the miners in their onward course. Along the bed, the process of working is the same as on the masses, the whole of the good salt being mined without leaving any support for the roof of the workings, there being nothing more than huge caves excavated entirely in the salt, which is seldom or ever worked through, either in the floor or roof of the caves, because as the salt approaches its matrix it becomes intimately mixed with marl, and is highly deliquescent from containing magnesia.

In almost every mine in the Salt Range the evil of having left no pillars for the support of their roofs, &c. is experienced, and some of the larger and best mines have been, in a great degree, abandoned, in consequence of their becoming filled up with huge masses of salt, gypsum and marl. As the marl is the lowest rock in the Range, and dips under all the others in a northerly direction at an angle of from 25° to 40°, as might be expected, much trouble is occasioned by the filling of the mines with water when they reach to any great depth. During the rains too, in July, August and September, the water rushes through passages in the marl into the mines, and by detaching large portions of rock, renders them quite unsafe. In these months, the miners desert the mines; partly on account of their danger, and partly on account of the intense heat and numerous fleas and musquitoes which infest them and their neighbourhood.

In consequence of the irregular way of carrying on the workings, the passages into the various mines exhibit at present a succession of ascents and descents over a series of rude steps, which sometimes become so polished and slippery as to render walking over them a matter of some difficulty.

In extracting the salt, the chief instrument used is a hammer, pick-shaped and hard-tempered at one end, and with a round head at the other. A mass of salt being fixed upon as the scene of operation, a portion is lined off, about two feet thick, and along this a groove is cut with the sharp-pointed hammer to the depth of some eight or ten inches. Larger sharp-pointed hammers as wedges are then introduced at intervals along this line and on their broad heads a series of sharp blows are inflicted. This generally detaches a block of salt, which is then broken up into lumps of a size convenient for being carried out of the mines. The amount of waste resulting from the above method of working is something immense, and as powdered salt is not saleable as long as lumps can be had, it is generally shovelled into the bottom of the workings where frequently there is a deep brine pool ready to receive it.

Instead of making a deep groove along the limits of the mass it is desired to detach, (we believe the object could be equally well attained by adopting the plan used in the granite quarries of Scotland, and which is as simple as it is effective) small holes, three or four inches long, two inches broad and four inches deep, are picked out at intervals of eight or ten inches in the mass which it is desired to split. Into these holes truncated iron wedges are introduced. Each of these is in succession driven into the holes and continue to receive sharp blows till the mass splits, which is at once known by the elasticity of the stone causing the wedges to jump out of their holes. A lever is then inserted into the crack and the divided portions separated. Were this process introduced in the mining of the salt, we are satisfied that a considerable saving to Government would be effected. On account of the dangerous state of the roofs of nearly all the mines, gunpowder is seldom used, and hence all the work is done by the pick and hammer.

The mines are generally very faintly lighted by small oil lamps made generally out of bits of salt, the glimmer from which

reflected from the sparkling mineral and salt-encrusted bodies of the workmen has a most singular effect. From the want of circulation of air in most of the mines, and the dampness of the atmosphere, the heat is most oppressive, and from the filthy habits of the miners, the stench in some of the mines is quite overpowering. In the month of December when the temperature of the external air was 71° in the Bugee Mine at Keura, the thermometer indicated a temperature of 81°.

Men, women and children indiscriminately pursue the avocation of salt miners. Families generally work together, the mother and children being chiefly occupied in carrying, on their backs, the masses of salt from the workings to the mouth of the mine, which the father has quarried. Like miners generally, they are a somewhat discontented set, and strikes among them are by no means uncommon.

The pay of the miners varies a good deal. At Keura, Mukrach and Vurcha, salt is turned out at the mouth of the mines, at the rate of Rs. 3-12 per 100 maunds (£0-7*s*. 6*d*. for 8,000 lbs;) at Surdee they receive Rs. 2-8 (£0-5*s*. 0*d*.) while at Kalabag, where the salt occurs in enormous masses which crop out on the surface of the marl, and which have only to be broken up and removed, they receive Rs. 2-14 for quarrying it, and Rs. 1-5, per 100 maunds, for conveying it to the depôt at Maree, The above rates include the expense of oil, instruments, &c., all of which are supplied by the miners themselves.

The quantity of salt that can be turned out in a day by a good workman is about 10 maunds (800 lbs.) which at the present rate of Rs. 2-8 per 100 maunds would give the miner 4 as. or 6 pence. Where, however, a family work together, the father, and perhaps one of the sons, mining, while the mother and children remove the salt, their earnings amount to something considerable.

The general appearance of the miners varies greatly. At the end of the hot season they appear very sickly and sallow, but towards the close of the cold weather they do not appear to us to have a more unhealthy aspect, than the inhabitants of towns in the Punjab generally have.

They however suffer a good deal from sickness; but this is probably more owing to the position in which their villages are placed, and to their filthy habits, than to their trade. Certain diseases, such as ophthalmia and pulmonary complaints, are very prevalent among them, and doubtless result from the injurious effect of the finely powdered salt acting as an irritant on the mucous membranes. Fever is very prevalent among the miners at Keura, where, perhaps from the confined position of their village, they look far more sickly than at most of the other mines.

Goitre is a frequent complaint, but particularly so at Kalabag, where every one seems more or less affected by the disease. This the natives ascribe to the Indus water which is generally of a milky colour from fine calcareous mud mechanically suspended in it, and which the addition of a little alum speedily removes.

Dracunculus, or guinea-worm, is also very prevalent, but is by no means peculiar to the Salt Range, being a common complaint all through the Punjab among the natives, whenever they are dependent on tanks for their supply of water.

As a general rule it may be observed, that where the supply of water to a village is obtained from a kucha (mud) tank, out of which men and cattle drink, indiscriminately, a circumstance, from necessity, by no means uncommon, there guinea-worm will prevail, while in villages supplied by running streams, the disease will be unknown.

During the Sikh rule, salt was mined at almost every spot where it cropped out, but to prevent smuggling, most of the mines have been shut up since the annexation of the Punjab, salt being now only extracted at Keura, Mukrach, Surdee, Chooa Vurcha and Kalabag. At all these places there are regular salt depôts, and there only can merchants procure a supply at the rate of Rs 2 per maund (£0 4*s.* 0*d.* for 80 lbs.) For whatever quantity they may purchase they receive a permit, and should an ounce more than this indicates, be found in their custody, confiscation of the salt, and of the mules, bullocks, or camels, on which it is loaded, is the punishment awarded.

To prevent smuggling wherever salt occurs in the marl, or is supposed to, from the occurence of strong brine springs, a guard is posted, and the villagers are not allowed to take away, even for their cattle, the saline efflorescence on the sides of the numerous brine streams, which issue from the range or even a pitcherful of the brine itself. As only the very poorest class of natives would think of using the dirty salt on the sides of the streams, or of evaporating the brine in order to obtain a small supply, this proscription falls very hard upon them, and they cannot understand why they may not as well avail themselves of the kulur or koura panee as allow it to be wasted.

Of all the mines in the Salt Range, those at Keura, near Pind Dadun Khan, yield the largest amount of salt, and those of Chooa Vurcha the least. The annexed table, the materials for the construction of which we are indebted to W. Wright, Esq., Collector of Salt Customs in Punjab, shows the quantity of salt extracted from the mines at each of the different salt stations or depôts during the commercial years, 1850 and 1851, with the amount of revenue realized by its sale :—

	1850.			1851.		
	Maunds.	Seers.	Chitacks.	Maunds.	Seers.	Chitacks.
Keura mines,	4,63,140	14	2½	3,84,242	19	11
Mukrach ditto,	1,46,525	5	0	1,31,773	23	6
Surdee ditto,	42,505	20	0	19,628	31	4
Choa Vurcha ditto,	36,385	2	8	39,699	26	0
Kalabag,	79,747	23	2	65,274	7	6
Grand Total,	7,68,603	24	12½	6,40,618	27	11
	R.	A.	P.	R.	A.	P.
Revenue yielded at the rate of Company's Rupees two per maund of forty seers,	15,37,400	1	7	12,81,295	14	10

The introduction of a scientific system of mining a mineral which yields so large an amount of revenue to Government, is of such vast importance that we cannot close our remarks on the salt deposit, without urging the necessity of securing the services of a practical miner, who from extensive experience, acquired under-ground, in some of the large salt mines of England or the Continent, is thoroughly capable of introducing and carrying out the improvements required. Under his guidance, the mineral should be extracted, shafts sunk, and the whole interior economy of the mines regulated.

The operations now in progress, with a view to run a tunnel into the Sujeewala mine at Keura, now from the effects of the former primitive way of working it, is almost entirely blocked up, are, we trust, only the commencement of a series of reforms, which if carried out, with vigour, by duly qualified superintendents, are certain to be followed by the best results. It will probably, however, be found more economical and satisfactory to sink entirely new mines through the marl into the salt bed, than to attempt radical changes in mines that have been long worked, and have had their roofs extensively undermined by

the indiscriminate excavation of salt. The waste in working the salt is now so great, that we are convinced, with a little care and the introduction of an improved system of mining, a large amount might annually be saved to Government. It is not enough to say that because the supply of salt is so abundant, there is no necessity for changing the method of mining that has been adopted from time immemorial.* The supply of salt is undoubtedly large, but as there is such a deal of difficulty, nay impossibility, in the present state of the workings, of obtaining accurate information as to its extent or thickness, we conceive it is the duty and interest of an enlightened Government to economize the mineral as much as possible. The powdered and inferior salt, now wasted in the mines, might all be saved by dissolving it in water in deep tanks. In these all mud and other impurities would rapidly subside, and on the brine solution becoming clear, it might be run off and evaporated by the heat of the sun in other shallow tanks, or by passing the brine through mattings exposed to the sun and air, on which it would rapidly crystallize. In the Austrian mines, the brine obtained from impure salt is dried up in large evaporating houses, but as in this country the heat of the sun would serve instead of fuel, the expense would be but trifling, and a large quantity obtained of a salt, which for many purposes, would be preferrable to rock salt.

By economizing also the numerous brine springs and streams which issue from the Salt Range a large supply of an inferior salt could be obtained, and which, if sold at a cheap rate,

* We have been quite unable to obtain any accurate information as to the period when the salt mines were first opened. The natives assert it was during the reign of the Emperor Akbar (whose accession dates from 1556) to whom the existence of salt in the Salt Range was disclosed by one Asp Khan, on condition of his receiving, as a reward, during his life time, a sum equal to the amount of the wages of the miners employed in extracting it. During Akbar's reign, it is a matter of history, that Lahor salt sold at the rate of about six anas a maund. In the Kohat district at the present time it may be brought for use Trans-Indus at four anas a maund!

would, we believe, be extensively purchased by the natives, for agricultural purposes.

A large quantity also of an impure salt (a mixture of chloride of sodium and sulphate of soda) might be collected from the banks of the Kulur Kuhar and Sumoondur salt lakes,* which is now utterly useless, the natives on their banks not being even allowed to remove it to give to their cattle.

Gypsum.

Gypsum occurs in the marl in a manner similar to the salt, irregular beds and huge masses being scattered through it. Wherever it occurs in beds it is much cracked, the fissures being filled with red marl or a bluish clay. Beds of it seem to lie both above and below the salt. In some localities the strata of gypsum are remarkably bent and contorted, as if they had been subjected to violent, lateral pressure, previous to their being shattered and upheaved. The mineral is for the most part of a light grey colour with a shade of blue, and translucent on the edges. It has a saccharine appearance, but masses in which a coarse crystalline structure prevails, are by no means uncommon. Red varieties also occur, and beds of a dark grey earthy gypsum are generally associated with the saccharine kind.

It is a nearly pure sulphate of lime and appears to be free of any admixture of carbonate of lime.

When calcined it yields a pure plaster of Paris, which sets rapidly when mixed with water. Gypsums, however, in which carbonate of lime is absent, form, when calcined, a less coherent cement than those where it occurs, to the extent of 10 or 12 per cent. By a due admixture therefore of quick lime with the

* The water of this lake has a Sp. Gr. of 1.02. Five hundred (500) grains evaporated to dryness, yielded 14.97 grains of saline matter consisting of sulphate of soda and chlorides of sodium and magnesium, with a trace of chloride of calcium.

calcined Salt Range gypsum, its hardness as a cement or mortar will probably be increased.

The natives do not appear to be aware of the properties of gypsum when calcined, though they use it in fine powder, mixed up with pure lime into a mortar, to produce the shining marbly appearance, so often noticed in their finer chunam work.

In the department of public works, the use of gypsum might be successfully introduced for various building purposes, and a supply to any extent might be procured from around Pind Dadun Khan.

In the gypsum of Maree and Kalabag, and also at Surdee, very perfect rock crystals occur generally in the form of six-sided prisms terminated by six-sided pyramids. After rain these spangle in a most striking manner, and hence have acquired the name of Maree diamonds. Transparent, red and milky varieties occur, the former being the most abundant. The longer and more perfect crystals are much esteemed by the natives, who manufacture them into necklaces.

Very perfect crystals of iron pyrites also occur in gypsum in the Keila Wan above the village of Khond, from beds, of which a sulphur spring issues at a natural temperature, depositing sulphur on the gypsum over which it flows.

In proceeding along the Salt Range from E. to W., the first indications of salt marl occur in the S. E. or scarped side of mount Tila, where it is very indistinct, being in great part concealed by tertiary sands and clays. From the West end of mount Tila it may be traced along the foot of the scarped or West side of the Chumbul ridge to Jelalpore where it is considerably developed, but in the midst of such great disturbance that its relative position can with difficulty be made out. To

the West of Jelalpore there is no distinct outcrop of the marl seen along the escarpment of the Range under the red sandstone until we reach Jutana, where it occurs in great quantity, and includes large stratified masses apparently of salt, along with broken up beds of gypsum. No salt is seen in the marl East of Jutana, though wherever it appears, its surface is covered with a saline efflorescence, and all the springs which issue from it yield a strong brine.

From this point it may be uninterruptedly traced to Pind Dadun Khan, in the neighbourhood of which it yields a very large amount of salt, and from thence with but a few breaks on to the Grechi Hills near Moosa Khel, between which place and Booree Khel it is not seen. Here it again crops out and yields salt, and may be traced westward for some two or three miles into a ravine, which separates the Lukrukee from the Majooch Hills. It then disappears and does not again, as far as we are aware, crop out, till near Maree on the Indus, where it forms an isolated ridge overhanging the river, along the right bank of which above the town of Kalabag it is extensively developed, the salt appearing in immense stratified masses in the marl. Except for a few miles up the Loon Nula, which enters the Indus, opposite Maree, we have not traced the marl northward, but probably the same formation yields the salt obtained at the mines in the Kohat district, which from the repeated attacks of the hill tribes have gained considerably notoriety.

At Maree and Kalabag, the marl appears to have been subjected to great disturbance, and the red sandstone strata, which in other localities are immediately superior to it, seem to be wanting entirely. At Maree a few Tertiary sandstone strata may be seen, dipping as it were under the marl, and on the Kalabag hill it seems entirely covered by Tertiary conglomerates and sandstones. As there is distinct evidence of a great upheaval and fracture of the rocks at Kalabag, it is not surprising

that the salt marl should appear to have suffered in the general disturbance, and to have, as it were, been forced up through the rocks, which in the regular order of things intervene between the Tertiary strata and the marl.

Its relation to the Tertiary rocks might induce the supposition, that at Kalabag the marl was of Tertiary age, but its general appearance and mineral character are identical with the rock to the eastward, and leave no room to doubt that it is of the same age.

Besides the general outcrop of marl along the escarpment of the Range, we have noticed it under the red sandstone on the N. W., or the scarped side of mount Kuringalee, the path between the villages of Chumbee and Vuhalee passing over it. Here no salt was observed, but the marl contains abundance of gypsum, and its surface is incrusted with the usual saline efflorescence. At the west end of the salt lake of Kulur Kuhar, the marl also occurs in small quantity, appearing to have been forced up through the rocks immediately superior to it, and to be brought into contact with nummulite limestone by which it is covered.

At Vusnal, to the north of Noorpoor, we believe the salt marl with salt occurs in a deep ravine, but as we were not aware of the fact when in its neighbourhood, we never visited the locality. This, as far as we know, is the only spot where salt has been found on the north side of the Salt Range.

b. Lower Red Sandstone and Grit with Conglomerate.

Wherever the salt marl is seen at the base of an escarpment, its upper portion may be observed gradually to lose its brick-red colour, to become more like an indurated clay, and ultimately to pass into thin beds of dark red, fissile, argillaceous sandstone, which in some places alternates with thin beds of gypsum and salt, and with green and chocolate-coloured clays.

This sandstone gradually loses its argillaceous character, its beds become thicker, its colour lighter, and by its constituents becoming coarser, passes frequently into a grit. Conglomerate bands, chiefly formed of boulders of primitive rocks of moderate size, among which the prevalence of a red coarse-grained syenite is very remarkable, occur frequently, and present exactly the characters of the old red sandstone conglomerate of Britain.

The sandstone generally, but especially its lower beds, where they approach the marl, is highly hygrometric, and frequently presents on its surface a saline incrustation.

It does not disintegrate in muriatic acid, but a portion dissolves with effervescence, the solution yielding to the usual tests, abundant indications of carbonate of lime and carbonate of magnesia.

The ease with which this sandstone can be quarried is a strong recommendation in its favour, though from its liability to become damp in moist weather, owing to its being impregnated with salt, it rapidly crumbles, and hence cannot be recommended as a durable building stone. If, ever required for the purpose, the lighter coloured portions of the rock should invariably be selected, as they are less hygrometric than the darker variety.

No minerals of importance have been observed in this rock.

Although the most careful search was made, particularly in the lighter-coloured beds where fossils are most likely to be found, not a trace of an organic remain could be detected: when we bear in mind the fact that only a few years ago, the old red sandstone of Britain was regarded, "as the least fossiliferous rock in the geologic scale," our want of success in obtaining fossils from its Punjab representative, will not appear remarkable.

The thickness of this formation varies a good deal throughout the Range, and probably on an average is not less than 500

feet. The upper surface of the beds frequently present ripple markings, indicative of their having been deposited in shallow water.

c. Greenish micaceous Sandstones and Shales, with grey Dolomitic Sandstone.

The red sandstone is generally succeeded by a series of greenish micaceous thinly-laminated sandstones, dark shales and coarse calcareous bands, which in the eastern part of the Range are developed into an extensive deposit of a very peculiar sandstone, varying from nearly white to dark grey, and weathering of a fawn colour. In many localities it is brecciated, the fragments having become recemented by a calcareous paste. A concretionary structure is, by no means, uncommon, masses of the rock appearing to be sometimes made up of nodules, formed of concentric laminæ like the coats of an onion. Its lower beds are generally dark-coloured, and parted by bands of micaceous sandstones and shales; brine-springs not unfrequently issue from these and their impregnation with magnesia is evinced by the effervescence of sulphate of magnesia in fine acicular crystals, which may be often observed under the ridges of rock. When tolerably well developed, the united thickness of this formation must be about 500 feet.

The grey sandstsone, when treated with muriatic acid, dissolves slowly with effervescence, leaving a considerable residue of a nearly white silicious sand. On filtering this from the acid solution and applying to it the usual tests, lime and magnesia were found in abundance with a trace of protoxide of iron and alumina. The rock under notice is therefore a sandstone, the cementing agents being carbonate of lime and magnesia. Sometimes the two latter largely predominate, and give the sandstone more of the character of a coarse limestone. In a few of its beds, the cementing ingredient seems to be entirely carbonate of lime,

and the examination of a specimen from one of these bands obtained at Baganwala in 1848, which did not yield a trace of magnesia, led us to believe that this earth was not characteristic of the formation, which its appearance induced us to suspect.

A specimen of this sandstone from Mount Tila yielded, on analysis, the following results in 100 parts :—

White quartz sand,..	28.000
Carbonate of iron with a trace of alumina,...	7.313
Carbonate of lime,..	32.874
Carbonate of magnesia,................................	31.199
Loss, ...	.614
Total,...	100.000

This sandstone or coarse magnesian limestone will, we are assured, be found to be a most excellent and durable building stone, and it is much to be regretted, that it was not selected for the construction of the obelisk in the Chilianwala burial-ground, the red sandstone of Pind Dadun Khan having been preferred. Though rather hard, it is easily worked, and when roughly polished, is highly ornamental from its possessing a semi-crystalline structure.

It may be had in abundance on mount Tila, the summit of which it forms, and all along the Salt Range from Jelalpoor to Mukrach, to the West of which place it gradually thins out in the micaceous green sandstone.

Like most calcareous rocks, it is liable to be acted on by water charged with carbonic acid, and hence along the upper weathered surface of its beds, it is grooved and channeled in a most peculiar way by the rain water, which, passing through the vegetation, acquires carbonic acid in considerable quantity, and becomes a most powerful natural solvent of lime and magnesia.

The only mineral which we have observed in this formation deserving of notice is galena or sulphuret of lead.

This occurs in the dolomitic sandstone, forming the summit of mount Kuringalee, and in the same rock in a ravine near the temple on the right side of the Keura Gorge above Pind Dadun Khan. In these localities small cubical crystals are found scattered throughout the rock, but in very small quantity, and nowhere are there indications of a vein of any consequence. It is in great request among the natives as a cosmetic, to whom it is known by the name of Soorma.

Obscure carbonaceous markings are of frequent occurrence among the green micaceous sandstones, but too indistinct to be identified. They probably are the remains of fuci. In the dolomitic sandstone, no traces of organisms of any kind were detected.

d. *Upper, red, variegated Sandstones, Grits, Conglomerates and Clays.*

The dolomitic sandstone last described is succeeded by a series of dark red shales, argillaceous sandstones, including nodules of green clay, and quartzose grits with bands of conglomerates of primitive rocks, among which the same red syenite as occurs in the lower red sandstone is most abundant.

These beds are highly charged with peroxide of iron which gives them a blood-red colour, and magnesia may be detected in all the sandstones, grits, and conglomerates of the group in considerable abundance. All the sandstones are extensively ripple-marked, and along the water courses which intersect the beds, present on their surface a saline efflorescence.

Between Jelalpore and Pind Dadun Khan, they are largely developed, while towards the Indus they seem to be in a great

measure, re-placed by a series of red, green, purple, and chocolate-coloured shales, which weather gradually into clays, and from yielding small concretionary masses of copper ore, present considerable interest. These are invariably superior to the sandstone grits and conglomerates. Thin beds of white quartzose grit occasionally traverse the shales, and beds of a coarse silicious sinter, containing in some places particles of chalcedony, are of frequent occurrence. Throughout the shales selenite or transparent gypsum may be noticed in laminæ and crystals, and in small impure concretions of radiating crystals, associated with similar nodular concretions of impure sulphate of barytes and argillaceous hæmatite. These along with the silicious sinter, have probably been deposited by thermal waters penetrating the shales, the variegated colours of which may probably result from their having been exposed to different degrees of heat during the prevalence of thermal action. Such coloured clays, are, we believe, of frequent occurrence in countries where thermal action is prevalent.

On tracing the shales upwards, they gradually become arenaceous, and acquire a greenish colour. A few dark shales then follow and mark the transition into the formation which succeeds.

Copper Ore.

The existence of copper ore in the Salt Range was first made public by Capt. Hollings, Deputy Commissioner of Leia. It occurs chiefly in the form of nodular concretions, varying in size from a millet-seed to that of a walnut, disseminated through the variegated shales and clays resulting from their disintegration, on the surface of which, particularly after rain, their green colour brings them prominently into view. Small green patches of silicate and carbonate of copper may also be observed in masses of the silicious sinter, which, we before mentioned as

occurring in the shales. The origin of these concretions is most obscure, but it is probable that the particles of copper in solution in thermal waters were diffused through the shales, and that by a process of crystallization they have aggregated into the form we now find them. Their resemblance to the nodular concretions of kunkur, found every where in the desert alluvial soil throughout the Punjab, induces us to believe that they were formed in a similar way. So complete, however, has been the separation of the particles of copper from the shales in which they are found, that not a trace of copper can be detected in them on submitting small portions to chemical analysis.

The nodules of copper ore are occasionally very pure, but frequently it forms only the centre of the nodular concretionary masses of sulphate of lime and barytes, which we have above alluded to.

No indications of the existence of a vein of ore have been obtained, either in the shales or in any rock, superior or inferior to them. In the thin beds of coarse white quartzose grit which occur in the shales, disseminated grains of carbonate and silicate of copper are occasionally to be noticed, but in small quantity.

The ore, is, for the most part copper glance or sulphuret of copper, one of the richest and most easily smelted ores. Its surface is generally covered with copperas, the result of the action of air and moisture; indeed in a large number of the nodules, the copper glance can only be detected in their centre, their circumference being converted into carbonate of copper.

The purer and undecomposed nodules present on fracture a dark leaden-colour, and are sectile. Particles of the ore heated before the blow pipe on charcoal, yield a button of metallic copper.

A pure specimen yielded, on analysis, the following results in 100 parts:—

Copper,	75.830
Sulphuret of Soda,	3.155
Sulphur,	21.
Peroxide of iron and alluminæ,	.015
Total,	100.000

The above analysis shows a much larger percentage of copper, than the concretions usually contain. This, from a series of experiments, we believe, to vary from 12 to 20 per cent.

The quantity of ore seems insignificant, and is only interesting in a mineralogical point of view. After heavy rain, which disintegrates large quantities of shale, and leaves the green copper concretions exposed to view, a man may, in some localities, collect, in the course of a day, about an ounce of ore. It seems to be more abundant in some localities than in others. The Nulee hill above Kutha, yielding, we believe, the largest quantity. We have detected it in almost every deep ravine between Bazar East of Moosa Khel and Kutha, a distance of not less than forty miles, within which limits the variegated shales are principally developed.

The only indications of organisms we have detected in this formation, are confined to the dark red, schistose, sandstones, and upper arenaceous shales. They are most indistinct, and are probably the remains of Fucoids.

The rocks we have described under the term Devonian, form in thickness and extent, perhaps the most stiking feature in the geology of the Salt Range, appearing in its steep escarp-

ment subordinate to all the rocks hereafter to be noticed, and in the numerous ravines which intersect it.

On proceeding westward from Rhotas, they first emerge from under the miocene sandstones on the East flank of mount Tila, the great mass of which they form, all the sub-divisions of the series being duly represented in this mountain (see section No. 4,) with the exception of the copper shales. From its West end they may be traced across the Boona Nula into the Chumbul Range, where they are flanked to the East by the Eeocene sandstones of the Surafur hills. On the Gurjak hill above Jelalpore, they are extensively exposed, and form the mass of the Range on the Baganwala, where the upper red sandstones attain their greatest thickness. From this point they stretch North for several miles, dipping under the table land of Besharut, and rising up again to form the summit and scarped northern face of mount Kuringalee and Drengun, from whence they may be traced into Diljuba, where they are for the most part concealed by the extensive tertiary strata which stretch East to Bukrala.

From Baganwala westward the Devonian rocks can be traced uninterruptedly. Around Kutha, the copper shales first appear, and seem in a great degree to take the place of the upper dark red sandstones, which can scarcely be recognized between that locality and Moosa Khel, except in the neighbourhood of Chideru, where thick beds of them occur subordinate to the shales. From Moosa Khel on to the Indus, the Devonian formations above the salt marl seem to amalgamate, and the divisions which are so distinctly marked in the East part of the Range, can, with difficulty be made out, the thickness of the whole gradually diminishing. They disappear altogether around Maree and Kalabag.

In the Chichalee Range of hills, on the West bank of the Indus below Kalabag, no Devonian rocks crop out, but at the

North or upper end of the Kafir Kote Range, near the village of Bahadur Dok, a series of red and grey saliferous sandstones appear for a short distance under carboniferous limestone. Numerous brine springs issue from these, which are doubtless the equivalent of the Devonian rocks East of the Indus.

Primary or Palæozoic carboniferous Rocks,

Succeeding the formations last described are a series of limestones and sandstones which, from the abundance of marine organic remains they contain, furnish to the geologist a most invaluable aid in determining the age of various rocks inferior to them.

During the very partial examination of the Salt Range, which by orders of Government we made in the month of April, 1848, we detected at Moosa Khel on our return to Lahor from Kalabag, a developement of calcareous strata, which in our report we stated to be evidently superior in geological position to the salt marl. In a few hours devoted to the examination of this locality, a small collection of fossils was obtained, which were sent to England in order, if possible, to have them identified.

Through the kindness of Sir Roderick Murchison we effected this, and were informed by that distinguished geologist that the Moosa Khel fossils seemed identical with carboniferous forms well known in the British isles.

M. de Verneuil, to whom my collection was submitted, identified 5 out of 8 or 9 species with forms well known in rocks of carboniferous age in other parts of the world.

The circumstance of our having detected what we took for belemnites and ammonites, associated with generic characteristic of palæozoic formations, and misled by the idea entertained by

geologists until very recently, that salt deposits were confined to Triassic or more recent rocks, we had great difficulty in bringing ourselves to believe that the Salt Range salt could possibly belong to a formation older than the Trias. The recent announcement, however, of the fact, that in North America the great salt sources issue from the heart of palæozoic rocks, and that in Russia the salt lies chiefly in the uppermost palæozoic deposit, and also in the Devonian sandstone, immediately removed all doubts from our minds as to the true age of that of the Salt Range, as well as of the calcareous strata of Moosa Khel.

The rocks included under the term carboniferous present in the Salt Range three divisions, which we shall proceed to notice.

A lower limestone, calcareous sandstone, and shales.

The lower beds of this deposit, when they rest on the Devonian rocks, generally present the characters of a calcareous sandstone of a light grey colour. This gradually passes into a limestone of a very compact and generally crystalline character, varying from a light flesh colour to dark grey, some varieties being nearly black. The beds of this rock, in which occur irregular shaped masses of hornstone, sometimes closely approaching to flint, are frequently parted by thin bands of arenaceous shales. There are frequently a mass of corals and corallines mixed up with shells. The limestones generally abound in encrinites and large brachiopodous Mollusca, and in many localities seem to be composed entirely of the disjointed stems of the former. Their fractured surface presents generally a highly crystalline aspect from the encrinite whorls being converted into calcareous spar.

Although generally a purely calcareous formation, in some localities, especially towards the Indus and in the Chichalee hills, it seems to become magnesian and to alter considerably in general appearance. Wherever magnesia prevails, the lime-

stone assumes a cherty aspect, the strata are much disturbed, and frequently shivered, fossils become very scarce, and the same brecciated appearance as is noticed in the Devonian dolomitic sandstone is very common. The occurrence of magnesia in the limestone is very local, and the same bed may be observed purely calcareous and full of fossils at one point, while half a mile beyond, it is charged with magnesia and scarcely a fossil to be found in it. Although the transition from a calcareous rock to a magnesian one is generally noticed along the strike of the beds, the same change may be observed in some localities extending in a vertical direction; such phenomena have been observed by Sir Roderick Murchison in the Alps, and it has been supposed that the magnesia, subsequently to the formation of such limestones, has been injected into them, and produced a metamorphosis. The absence of fossils too amidst the magnesian limestones has been accounted for, by supposing that the mineral acid in union with which the magnesia has been introduced, has, in accordance with the known laws of chemical attraction, combined with the calcareous matter of the fossils, and caused their disappearance. A similar theory, to account for local deposits of gypsum in the midst of calcareous strata has also been propounded, viz., that vapours of sulphuric acid, generated during the prevalence of igneous action, have been injected into limestones, and have converted the carbonate into sulphate of lime. The origin of the Salt Range gypsum cannot, however, we conceive, be explained in this way; for if sulphuric acid vapours permeated the marl, they would in all probability have produced partial decomposition of the salt into sulphate of soda, an impurity not to be found in the mineral. The almost entire absence too of carbonate of lime from the gypsum, strengthens the belief that it was originally deposited as such.

On tracing the limestone upwards, its beds become thinner and less crystalline, and alternate with thin beds of dark magnesian micaceous sandstones and shales. At the upper limit of

these in the central part of the Range and Chichalee Hills as well as at Kafir Kote, a few thin beds of a compact slaty limestone, generally of a dark grey colour, occur, and seem to mark the transition into the next division.

b. Grey Sandstone and Shales.

The beds forming this series consist of micaceous fine-grained fissile sandstones alternating with beds of dark bituminous shales. Towards their upper limits the sandstones become more compact and of a reddish colour, alternating frequently with beds of slaty limestone, similar to those forming the top beds of the division of the series last described. In the upper compact sandstones, ripple markings are common, and in the Bukh Ravine above Moosa Khel we detected a most distinct exhibition of markings similar to those produced by rain or hail falling on sand or mud, when in a wet or pasty state. These occur on the upper surface on a bed of sandstone, and were traced along its strike for a considerable distance. The bed dips under other beds of a similar sandstone which present ripple-markings on their surface, and hence we may safely conclude that it has been formed on a beach on which water has ebbed and flowed.

Rain-drop-markings, similar to the above, have been noticed by Sir Charles, Lyell, in the states of Massachusetts and Connecticut in red sandstone of Triassic age.

In all the shales and in most of the sandstones of this series, magnesia prevails, and hence but few fossils occur, those that we have observed being confined to argillaceous sandstones in the immediate neighbourhood of calcareous beds, which are generally free of magnesia impregnation.

c. Upper Limestone.

The two preceding divisions of the carboniferous series are very distinctly marked wherever it is extensively developed, but

east of the Indus there are few localities where the Upper limestone is well seen. It forms the summit of Zamanee hill above Chederoo, (see table No. 8,) which is upwards of 1,900 feet above the plain. Here, in mineral character, it is undistinguishable from the more crystalline varieties of the lower limestone, and abounds in encrinites and brachiopoda. About ten miles further west in the Bukh Ravine which intersects the Salt Range between Numul and Moosa Khel, a grey limestone of a hard and cherty character occurs in a similar position, but, as far as we are aware, devoid of fossils. Its lower beds assume the character of a very fine grained sandstone, and rest on a yellow argillaceous limestone of very fine grain, similar to some lithographic limestones. This limestone dissolves in acid with the separation of a considerable quantity of yellow mud, and its solution yields indication of the presence of a small quantity of magnesia; a few indistinct indications of fish scales were noticed in it.

On the Zamanee Hill, the upper limestone is purely calcareous, and dissolved rapidly in muriatic acid, with the separation of a very small quantity of yellow mud. That of the Bukh Ravine, however, dissolves slowly, and in its solution magnesia may be detected by the usual tests.

On analysis it yields in 100 parts :—

Silica,	4.000
Carbonate of Lime,	69.200
Ditto of Magnesia,	25.809
Alumina with a little Peroxide of Iron,	.100
Organic Matter and Loss,	.891
Total,...	100.000

The lower fine-grained sanstone on which the above limestone rests, yields on analysis as follows :—

Silicious Quartz Sand, ...	36.000
Carbonate of Lime, ...	47.870
Ditto of Magnesia, ...	14.800
Alumina and Peroxide of Iron,..................	1.200
Organic Matter and Loss,.......................	.130
Total,...	100.000

On the west bank of the Indus in the Chichalee Hills, the upper limestone is far more distinct than on its east bank ; and is generally cherty and magnesian, and much shivered and brecciated. In the Kafir Kote Range, a highly bituminous sandstone of a dirty brown colour, appears to be its representative, from which large quantities of petroleum issue, this being probably derived from the spontaneous combustion of dark bituminous shales charged with pyrites, on which the sandstone rests, and which form the upper member of the middle carboniferous series.

Throughout the carboniferous rocks we have described, there appears no indication of true coal measures, which in Britain are invariably associated with the carboniferous or mountain limestone. The latter, in the south of England, forms the base of the coal formation, while in the Scotch coal fields, thick seams of coal alternate with beds of carboniferous limestone and are intercalated with limestone and sandstone beds of fresh-water origin. In the Salt Range, however, no fresh-water beds have been observed in the carboniferous series.

The limestones or marbles of this formation can be strongly recommended as highly ornamental and durable building stones

The compact flesh-coloured and nearly black varieties are perhaps to be preferred, as weathering more uniformly than those which are more crystalline. They take a fine polish, and may be obtained in blocks of any size. Vurcha would be a convenient locality for obtaining the flesh-coloured stone, while in the Nursing Wan, near Kutha, the black variety could easily be procured. The flesh-coloured limestone forms the gateway of the ancient fort of Kafir Kote, where it seems to have resisted the action of the atmosphere in a most remarkable degree, the blocks being as fresh as the day they were quarried.

As a source of lime, all the limestones of this formation are very valuable. The yellow argillaceous limestone mentioned as occurring in the Bukh Ravine, is, we believe, well adapted for lithographic purposes, and shales of considerable size might, with ease, be obtained.

Petroleum, in the carboniferous formation, has been noticed only in the Algud Ravine at Kafir Kote, where it exudes in considerable quantity from the upper brown bituminous sandstone, which is highly charged with it; where springs issue from the sandstone, in the small ravines which intersect its beds, large holes are dug which rapidly fill with water mixed with Petroleum. This, from its lighter specific gravity rises to the surface and forms a scum, by passing bunches of grass through which, the Petroleum or Lalira as it is called, adheres, and is removed into guras or earthen vessels placed for its reception.

Notwithstanding its most offensive smell, it is burnt by the natives in their lamps. It is also in great demand among the owners of camels, who extol its virtues as an external application to sores and the common cutaneous diseases to which that animal is subject.

Sulphuretted hydrogen springs issue from the carboniferous limestone in several localities. In the Bukh Ravine one issuing from the upper limestone indicated a temperature of 94° when the air was 71° in the month of February. The water on escaping from the rock, deposits sulphur, and gives a copious black precipitate with a solution of acetate of lead.

Fossils are very numerous throughout the formation.

The lower beds abound in Brachiopodous molluscæ, crinoideæ, corals, and corallines; of Brachiopoda shells, the genera Producta, Orthis, Spirifer and Terebratula are most abundant. Along with the Brachiopoda we have obtained one or two Gasteropoda, but these are generally scarce.

In several localities we have found large spines of a species of Cidaris, some of these being very perfect and tuberculated, the articulating end of the spine being well preserved.

Though this is the case, the shell of the animal occurs but rarely, and only, as far as we have observed, in comminuted fragments.

The abundance of crinoideæ is very remarkable, whole beds of rock being built up of encrinites, the whorls of which are frequently of large size, and occasionally are found in connection with their lily head.

Towards the upper part of the lower division of the series, where the limestone becomes argillaceous and thin-bedded, and alternates with coarse arenaceous shales, the Brachiopoda become scarce and give place to Cephalopoda, which animals characterize a marine zone, of less depth than the Brachiopoda which precede them, and generally occur in lias with muddy

bottoms. We have obtained examples of species of the genera Bellerophon, Goniatites (?) and Orthoceras. Associated with these, large spiral univalves of the genus Cirrus and Enomphalus are abundant, and, in the slaty limestone at the top of the lower division of the carboniferous series, and also in the middle division, a Cephalopodous shell, formerly considered an ammonite, but now constituted into the genus Ceratitis, abounds, and is generally associated with a small bivalve, probably a species of Passidonia. As Ceratites have hitherto been considered as characteristic of rocks of triassic age and peculiar to the muschelkalk, their occurrence, in company with undoubted carboniferous types, is highly interesting. We have placed the matter beyond doubt, having in our possession a specimen* which we obtained at Moosa Khel, in which two Orthoceratites and seven Ceratites are lying, side by side, in a slab 9 in. × 5 in.; Orthoceratites have never been found in strata superior to the carboniferous limestone, but abound throughout the older fossiliferous rocks.

Fossils having a considerable resemblance to belemnites, occur in the carboniferous limestone associated with the fossils we have alluded to. What they really are, we are unable to determine; but as a set of specimens were sent home to England, in March, at the request of Sir Roderick Murchison, we trust soon to hear the result of his examination of them. The exact determination of their nature is of considerable importance, as there is, perhaps, not a more established fact in geology than, that belemnites are confined to strata which succeed the trias; abounding in the lias, oolite and chalk, after which they disappear from the page of geologic history.

In the same flag limestone in which the Ceratitis occurs, Icthyolite remains were obtained in the shape of small sharp

* Through the kindness of Cavendish Johnson, Esq., Asst. Surgn. 3rd Regt. N. I., we are enabled to submit a drawing of this most interesting specimen, which we believe to be unique in the annals of Geology.

and finely-striated teeth covered with a shining brown enamel, small fragments of bone and one or two scales have also been procured, the identification of which, as well as of a rather extensive collection of fossils from the Salt Range, cannot be effected in our present position, with neither collections nor books of reference available. The whole collection will be sent home to England, where the fossils can be satisfactorily examined.

The following species of shells, from the Moosa Khel limestone were identified in 1849, by M. de Verneuil :—

Producta Cora.—D'Orbigny.
  „ costata.—Sowerby.
  „ Flemingii.—Sowerby.
Orthis crenistria.—Phill.
Terebratula Royssii.—L'Eveille.

On the above, Sir Roderick Murchison remarks, in a communication addressed to the Geological Society, in December 1850 ; " these fossils have already been known to have an enormous geographical range, the Producta Cora occurring in Peru, Spitzbergen, northern Europe, and the Sierra Morena of Spain, whilst two or three of the other species, have an almost equally extensive distribution."

The carboniferous formation, the thickness of which, when well developed, is probably not less than 1,800 feet, is entirely confined to the central portion and western end of the Salt Range. It first appears at Noorpoor in the Nilawan ravine, where a thin bed of a crystalline grey limestone, containing a few Encrinites and Terebratulæ, may be seen resting on purple Devonian shales and covered by a ferruginous claystone which marks the base of the nummulite limestone formation, to be hereafter described. On tracing it westward, it gradually increases in

thickness. Productæ and Spiriferæ appear, and in some places literally swarm. At Kutha it is extensively developed in the Nursingwan, where high cliffs of it may be seen resting on Devonian rocks.

Between Kutha and Moosa Khel, it perhaps attains its greatest thickness, frequently appearing in scarped precipices and forming the mass of the hills which intervene between the south side of the Salt Range and the Sone-Sikesur valley.

In this district, rocks, probably of an oolitic age, appear between the carboniferous ones and the nummulite limestone, and this relation may be observed on to the Indus and in the Chchalee hills.

For a short distance on both sides of the Indus near Maree and Kalabag, the carboniferous rocks disappear; but at Kooch, about four miles North of Kalabag, they again crop out at the base of the Chichalee range, and may be traced south to near Mola Khel, where they are covered up by the oolitic and tertiary formations.

They again appear on the right bank of the Indus, below the village of Bahadur Dok, and constitute the greater part of the Kafir Kote Range, (washed by the Indus,) beyond the upper part of which we have not traced them. As this Range stretches south, and is evidently a branch from the great Sooleeman Range, it is probable that the carboniferous rocks occur there also, but the hostility of the hill tribes in its neighbourhood will, we fear, for years to come, prevent any attempts to gain a knowledge of its geological structure.

In the Kafir Kote Range, as far as we have had an opportunity of examining it, the carboniferous rocks are immediately in relation with tertiary sandstones and clays, no nummulite

limestone or oolitic rocks intervening; unless the bituminous brown sandstone, which we now consider the representative of the upper member of the carboniferous series, should turn out to be Oolitic.

SECONDARY OOLITIC ROCKS.

a. Yellow, iron-stained, quartzose, grits and bituminous shales.

Resting on the upper carboniferous rocks, and separated, from them, by a few thin beds of a yellow argillaceous limestone, there occur a series of fissile argillaceous sandstones, and coarse quartzose grits and sandstones, generally of an incoherent character, alternating with beds of black bituminous shales charged with iron pyrites. The prevailing colour of the sandstones is a sickly yellow, derived from impregnation with peroxide of iron. Masses of fossil wood, converted into jet, are abundant, both in the sandstones and grits. These also in some places occur in the shales, which, where exposed to air and moisture, are in a constant state of decomposition, from the oxidation of their contained pyrites. So violent is the action, and so great the heat produced, that sometimes the shales undergo spontaneous combustion, and whole beds may be observed either converted, or in process of being so, into a ferruginous claystone of a dark red colour, which occasionally presents a kind of concretionary structure.

In the neighbourhood of these decomposing shales and claystones, the sandstones and grits acquire a whitened and baked appearance, and the masses of jet they contain, are frequently converted into choke.

Where the shales are moist, their surface is generally incrusted with an efflorescence of sulphate of iron and alumina,

which strongly impregnate the water of springs which issue from them in some ravines, and which, on exposure to the air, deposits on the ground over which it flows a crust of hydrated peroxide of iron. In some of the shale beds in the upper part of the series, a magnesian efflorescence has been noticed, but the sandstones and grits seem altogether free of magnesian impregnation.

The lower argillaceous beds occasionally contain very perfect impressions of the delicate fronds of ferns, converted into black carbonaceous matter. These are doubtless of fresh-water origin, and, from the fineness of the sand and mud, of which they are composed, must have been deposited in still water.

The grits which succeed them and contain masses of jet, are also probably of fresh-water origin; but the fact of the latter being found only in masses, which are evidently portions of the trunks and branches of trees and invariably in a horizontal position, affords proof that they have been transported from a distance along with the coarse materials forming the grits.

No marine organic remains occur throughout these beds, which are succeeded by others of undoubted marine origin, and differing greatly in mineral character.

b. Cherty thin-bedded limestones, with shales

The sandstones, &c. last described, gradually acquire calcareous matter, and pass into fine-grained limestones of a cherty character, varying in colour, from nearly black to a pale yellow. East of the Indus, these beds are of little thickness, and contain very few organic remains.

At Kalabag and in the Chichalee hills, they alternate with yellow calcareous sandstones and dark bituminous shales, and

attain a thickness of three or four hundred feet in some localities.

Marine organic remains are abundant, particularly in the upper limestones, and some of the intermediate beds are a mass of comminuted shells.

Throughout the Chichalee Range, a very singular brown calcareous bed occurs, near the bottom of the series, in which small globules of a bright metallic lustre may be observed mixed up with comminuted shells. On treating a fragment of this rock with muriatic acid, the calcareous matter rapidly dissolves, leaving the globules in the form of a coarse sand, the particles of which have a highly polished surface, and have all the appearance of being the debris of hypersthene rock.

No distinct oolitic structure prevails throughout the limestones, which differ totally in appearance from those of the carboniferous rocks. Some of them bear a close resemblance to the limestones of the lias formation.

They are hard and splintery, and present a conchoidal fracture. When bruised, the darker varieties emit the odour of sulphuretted hydrogen.

They dissolve rapidly in muriatic acid, leaving a considerable sediment of silica in flakes mixed with a little organic matter. They contain a little carbonate of iron with a trace of alumina, but no magnesia, when undisturbed. At Kalabag, however, where large masses of the limestone repose on salt marl, they have a remarkably shivered appearance, and magnesia may be detected in them in small quantities. A specimen of the limestone of a dark grey colour from Mulo Khel in

the Chichalee Range, yielded, on analysis, the following results :—

Silica with a little organic matter,..........	3.00
Carbonate of iron with a trace of Alumina,..	1.70
Carbonate of Lime,.........................	95.70
	100.40

At Mola Khel a bed of argillaceous limestone occurs, presenting, on its upper surface, a series of waves passing across the bed at right angles to its strike. These are about 1½ feet apart, and their crest about two inches above the general level of the bed. It presents the appearance represented in the annexed figure. A bed of shale, which occurs beneath it, is, for a short distance, affected in a similar way; but the surface of a limestone bed on which

the shale rests, is perfectly horizontal, and does not seem to have suffered, in the least, from the lateral compression to which the upper bed has been subjected. The force exerted seems to have been nearly sufficient to have fractured the bed, as, along the crests of some of the waves, and parallel to these, cracks may be observed extending some depth into the bed, which is not more than two feet thick. It is difficult to imagine how any lateral force could have been applied, so as only to affect one or two beds. The condition of the beds, superior to the waved one, could not be ascertained, on account of the amount of debris with which they were covered.

c. *Green belemnite, Sandstone and Shales.*

In the Salt Range East of the Indus, the limestones last noticed, are succeeded by a thin bed of yellow quartzose grit,

containing a few fragments of jet. At Kalabag, and in the Chichalee Range, a series of black bituminous shales, succeeded by a dark green somewhat incoherent sandstone intervene, presenting a thickness of four or five hundred feet. The latter is full of pyrites, which rapidly decomposes after rain, sulphurous acid being given off in quantity at times sufficient to be disagreeable.

Small fragments of jet occur in the sandstone, and both in it and the shales, belemnites and ammonites occur in great abundance. These fossils are of great interest, as enabling us to fix the age of the formation.

All along the Chichalee Range the belemnite shales and sandstone are well developed, and are succeeded by the quartzose grit noticed above, which apparently contains no fossils.

In the oolitic formation, there are no building stones of any value; but many of the limestones are valuable as a source of lime.

Of minerals, we shall notice the bituminous shales, iron-alum, jet, or fossil wood, and argillaceous iron-stone.

The bituminous shales which alternate with the sandstones and grits are occasionaly used, at Kalabag, in the preparation of alum. Some of them are well adapted for this purpose, but, generally speaking, they are very inferior to the shales of the nummulite limestone formation to be hereafter described.

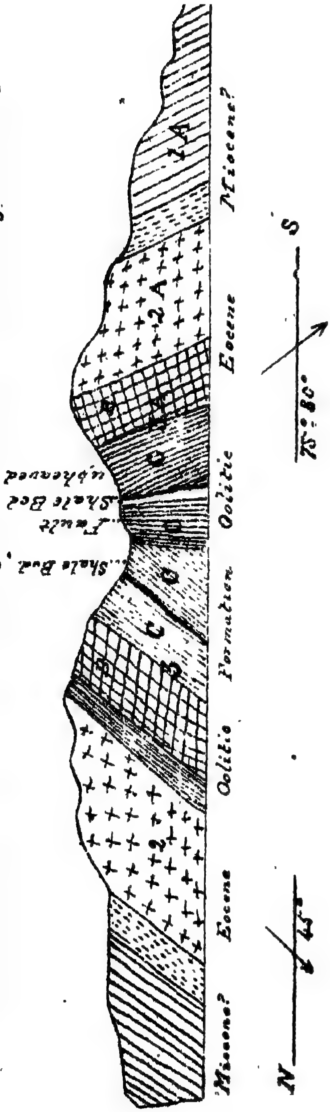
Iron-alum forms, as before mentioned, an incrustation on the surface of the bituminous shales and masses of jet, which contain iron pyrites in a state of decomposition. It is called "Kaie" by the natives, and is extensively used by them, when

mixed with an infusion of pomegranate or other astringent bark, containing tannin for the preparation of a black dye. Its colour is white with a tinge of yellow. It gives a strong acid re-action, and has a most powerfully astringent taste. Peroxide of iron and alumina are indicated in its solution, by the usual tests, in union with sulphuric acid. In the Bukh Ravine at Moosa Khel, it is collected in considerable quantity.

Fossil wood in the form of jet occurs in too insignificant a quantity, in the Salt Range East of the Indus to have attracted much attention. In a ravine, however, about a mile west of Kalabag, it occurs in considerable abundance, and under the designation of Kalabag coal has been employed within the last two years to some extent as a fuel in the Indus steamers. Its existence was, I believe, first brought to the notice of Government by Burnes and Wood, and has since been reported on by Dr. Jameson and myself.

It is found in lumps of various sizes in dark bituminous shales, alternating with yellow sandstones; but nothing like a seam has been detected, though films of bituminous coal may, in some places, be seen in the shales. The masses of coal are generally compressed, and are evidently portions of the trunks and branches of trees, the point of junction of the former with the latter being often apparent.

Though distributed throughout all the shale beds, the coal occurs most abundantly in one of these, which is from six to eight feet thick, and is enclosed between beds of yellow sandstone; in which masses of the coal also occur. It has, for the last two years been chiefly obtained from the shale-bed at a point where, owing to a fracture and upheaval of the strata, a portion of them have been thrown into a nearly vertical position, as represented in the annexed rough sketch.



Sketch Section across the Kalliragh hill, about a mile west of the town

Line of section from North to South, distance about 1 mile.

1—Conglomerate, soft sandstone and red clays.

2—Nummulite limestone and alum shales.

3—(A.) Belemnite shales (B.) cherty limestones.

(C.)—Quartzose sandstones and grits with beds of bituminous shales.

3 A., 2 A. and 1 A.—The same beds in reversed order.

By digging a succession of holes at different heights in the vertical shale-bed, the masses of coal are obtained with much greater ease, than where the bed, in a regular position dips to the north at an angle of 45° under the superior rocks.

In the vertical bed, a gallery has been sunk to the depth of fifty feet, in hopes of discovering a seam of coal, but, as was to be expected

with an unfavourable result. Indeed, the labour expended in digging the gallery, has not been rewarded, by obtaining a larger quantity of coal, the masses of which, we were informed by the miners, became less numerous and more difficult to detach from the shale, the deeper they dug. As it is most probable that the wood, now converted into coal, has been drifted from the spot where it grew, it is natural to infer, that the masses of it would accumulate more abandantly in some places than in others, just as drift wood does on the bank of a river. This appears to be the case at Kalabag, as in some places the shale contains numerous masses of coal, while at others scarcely a fragment is to be detected.

The coal has a bright glistening appearance, is very hard and light, and exhibits a conchoidal fracture in which its woody structure is most apparent. It is of a jet-black colour, has a brown streak, and often encloses nests of half-decomposed wood resembling peat. The surface of the coal often presents small crystals of gypsum, and imbedded masses of iron pyrites are by no means uncommon.

It burns quickly, without coking, to a light coloured ash, and emits a large amount of yellow smoky flame; on being distilled, it yields a light spongy coke of a glistening metallic colour with a large quantity of inflammable gas. On analysis the following results were obtained in 100 parts:—

Carbon (coke),....	37.5
Volatile bituminous inflammable matter, ...	60.0
Ashes (Silica), ...	2.5
Total,....	100.0

The large amount of volatile bituminous matter, as compared to that of coke, at once refers this coal to the class of

lignites, or coals in which the vegetable matter is imperfectly carbonized. In its small amount of ash, (which, in some specimens we have found as low as 1.66 per cent.,) it differs remarkably from most of these, but the solid nature of the wood forming the coal, not admitting of the infiltration of earthy matter, may account for this.

In an analysis, however, such as the above, the amount of ash obtained will invariably be less, than if a large sample of the coal were operated on, as the masses have invariably attached to them, portions of the sand, clay, &c., in which they were imbedded. These mechanical impurities fusing and forming a slag or clinker in furnaces, during the combustion of the coal, have been found troublesome.

The Kalabag coal is, for ordinary steam purposes, an excellent fuel, but not an economical one, on account of the rapidity with which it burns.

The real evaporative power of coals is in the direct ratio to the amount of carbon or coke they contain, and hence, as good English coal yields from 50 to 70 per cent., Kalabag coal should have only half their evaporative power, and about twice that of the ordinary woods used as fuel in the Indus steamers, which yield from 16 to 18 per cent. of solid charcoal.

The coal can only be procured in small quantities at a time, months being required to collect a few hundred maunds. During 1850, about 2,500 maunds were dug, and from the 27th March, 1851, to the 11th March, 1852, 2,126 maunds were turned out and landed at Kalabag, on the right bank of the Indus, at the rate of eight maunds for the Rupee, a rate which never can remunerate the miners for any length of time for the labour required to extract the mineral.

The ordinary small Indus steamers consume English coal at the rate of 600 lbs. an hour, when steaming, and hence on the supposition that double the quantity of Kalabag coal is required, 200,000 lbs., (2,500 maunds,) the out-turn of coal for one year, at Kalabag, would only keep one vessel steaming for 166 hours. We see no prospect of the supply of coal increasing, nay, the quantity obtainable, as far as we could ascertain from intercourse with the miners, seems gradually decreasing.

In the absence of any thing like a seam of coal at Kalabag, we do not consider it expedient for Government to spend money there in sinking exploratory shafts.

The coal has all to be carried on bullocks, mules or donkeys, from the pits to Kalabag, over a tolerable hill road, but as it is very hard it stands carriage remarkably well.

Clay iron-stone has not been observed East of the Indus, but in the oolitic shales at Mulo Khel, in the Chichalee Range we detected several thin beds of it, none of which exceeded 1½ or 2 inches in thickness.

It is of a dark grey colour and has a high specific gravity.

It dissolves with slight effervescence in aqua regia, leaving a considerable residue of dark mud. The solution is of a dark yellow colour, and gives with ammonia a dense brown precipitate of peroxide of iron mixed with a little alumina.

It is therefore analogous to the black band ironstone of Scotland, which, occurring as it does in connection with coal, is perhaps one of the most valuable iron ores known.

It would be interesting to ascertain if this ore is ever used at Kuneegoorum by the Wuzeerees, to yield the iron manufactured there, and which is brought into Kalabag for sale in lumps of very coarse pig-iron. We believe hæmatite ore is chiefly employed, but from what rock it is procured, we could obtain no information. Charcoal is used for the smelting of the ore, no other fuel being accessible.

The beds of clay iron-stone above noticed are too small to be of much practical importance, and, even did thicker beds exist, the want of a suitable fuel for the fusion of the ore, would prevent its being smelted at any thing like a remunerative rate.

In the lower argillaceous sandstone beds of this formation, we obtained at Moosa Khel, and also in the neighbourhood of Kalabag, very perfect carbonaceous impressions of the delicate fronds of a small fern, probably a species of Pecoptèris. These were associated with small pieces of brown coal, which are evidently the compressed stems of soft vegetables. Their remains, however, were too indistinct to admit of their being identified. The masses of jet described as Kalabag coal, present on fracture, a woody structure similar to that of the wood of Coniferæ or Cycadaceæ, numerous concentric circles of growth pierced by medullary plates being apparent in most specimens. Some Penteus, Ostreæ, Terebratulæ and fragments of Echinidæ occur in the limestones, in the upper beds of which a few belemnites were detected.

These latter however abound in the shales and green sandstones which succeed the limestone, and are associated with Ammonites, Grypheæ, Plagiostoma and Saurian remains.

The number of belemnites in the shales in some places is

quite wonderful, and two species at least occur. The alveoli of the belemnites are frequently found attached to the osselet, and in their interior the casts of the chambers of the alveolus or phragmacone. These are often found detached, and when seen in the rock, have much the appearance of an orthoceratite, being composed of concavo-convex discs, fitting one into the other, and having their articulating surfaces highly polished. Indeed were it not for the want of a siphuncle, and the ease with which each disc can be separated from its neighbour, the similarity to an orthoceratite would be complete. Each disc seems entirely disconnected from its fellow; but no partition of the original chambers could be detected between them, the convex surface of the upper disc being capable, apparently, of free movement on the concave surface of the lower one, as in a ball and socket joint. These discs are sometimes of large size, one specimen which we procured being two inches in diameter.

Ammonites, though occurring in the shales, are most abundant in the green sandstone. They are generally ill-preserved and are liable to fall to pieces in extracting them, having been acted on by the sulphurous acid, which is generated in the sandstone by the decomposition of pyrites. Two or three species have been procured.

Of the genus Gryphea, we have obtained probably two species, one of which closely resembles the G. incurva. They are generally ill preserved.

A large bi-valve, probably a species of Plagiostoma, is very abundant in the green sandstone, but good specimens are with difficulty procurable.

In some places, bones and teeth of Saurians occur in the sandstones, but are no where plentiful. The bones are gener-

ally fragmentary, very brittle and crumbly. Nothing like a complete skeleton was observed, the most perfect relic obtained being a portion of a scapula attached to a bit of a humerus. The teeth are better preserved than the bones, but are also very brittle. They are covered with a dark brown enamel, are compressed, sharp pointed, and beautifully striated on their surface. One, which we found, but which fell into fragments in attempting to extract it, was at least three inches long and about an inch broad at the base. The decomposition which the sandstone is undergoing near the surface, destroys, rapidly, the fossils which are imbedded in it; and hence, to obtain good specimens, the fresh rock must be quarried. This we had neither the time nor means of doing at our command, and hence were reluctantly forced to be content with such specimens as we could procure from the decomposing rock.

A claw, apparently of a crustacean, was observed in the sandstone, but it fell into fragments in digging it out.

All the fossils we have noticed are characteristic of the lias and the oolite; but from the general aspect of the rocks we have described, we are inclined to refer them to the latter formation. The green sandstone and shales are probably analogous to the Oxford clay; but an examination of the fossils, by competent palæontologists, can alone decide the point.

A formation abounding in oolitic fossils similar to those we have noticed, has been described by Capt. Grant, Bombay Engineers, as occurring in Kuch; and Capt. Strachey has also detected a like formation in the Himalayas, both on their Indian and Thibet sides. In the Rajmahal hills, Dr. McLelland, on the slender evidence afforded by the existence of a few species of fossil plants of the genera Zamia, Tæniopteris and Poacites, refers " certain greyish and bluish white indurated

clays, rendered slaty in places by the abundance of leaves of plants they contain," to the inferior oolite.

No oolitic rocks appear in the Salt Range in its eastern part. In the hills South of Koofree, at the West end of the Sone Sikesur valley, a few shales and sandstones here and there appear under the debris of nummulite limestone rocks. Their thickness gradually increases in a westerly direction; and, on the steep south-east side of mount Sikesur, the oolitic strata are distinctly seen between the carboniferous limestone and nummulitic rocks. From mount Sikesur, they may be uninterruptedly traced towards the Indus, preserving throughout a remarkably uniform character. From Kalabag they stretch round into the Chichalee Range, preserving the same relations as in the Salt Range, but are of great thickness. Excellent sections of them are obtained in the Chichalee pass and in the Ravines, between that and Mulokhel, about six miles below which they seem to throw out and to be covered up by nummulite limestone. They do not appear in the upper part of the Kafir Kote Range, as far as we have observed, but it is probable that oolitic strata again re-appear in the Sooleeman Range, as we have seen belemnites brought by natives from the hills near Dera Gazee Khan. These may probably be an extension of the Kuch strata before alluded to.

Tertiary Eocene Rocks, Brown Calcareous Sandstone, Nummulite, Limestone, Marls and Alum Shales with Lignite.

A band of claystone, in some places highly ferruginous, and in others nearly as white as pipe clay, seems to mark the base of this formation. It has exactly the appearance of the ferruginous claystones described as occurring in the Oolite shales, and as it may be seen occasionally passing into black bituminous shales

which are in rapid process of decomposition, its origin is doubtless identical.

Resting on this is an incoherent greenish brown calcareous sandstone, which, east of Kutha, is devoid of organic remains. At this place, however, it becomes more calcareous, contains a few nummulites and a considerable number of gasteropodous molluscæ. On proceeding westward to Moosa Khel, the bed becomes a coarse arenaceous limestone, and abounds in fossils similar to those which occur throughout all the rocks of the nummulite limestone series, none of those characteristic of the formations inferior to it having been detected.

To this sandstone there succeeds a deposit of very varying thickness of dark bituminous alum shales containing irregular beds and films of a coal having all the characters of a lignite. The shales contain much pyrites, and large and small crystals of Selenite are abundant throughout them. In many places they are undergoing rapid decomposition from the oxidation of the pyrites. In the neighbourhood of Kalabag the chemical action is so violent, and often produces such intense heat, as to cause the combustion of the shales, and their conversion into red claystone. In some of the old shale pits (from which the alum shales are dug) the combustion is most violent, and volumes of smoke issue with considerable force from their mouths, charged with the vapours of sulphurous acid which taints the air all around. On tracing the shales upwards they become arenaceous and marly, and pass by a coarse yellow marly limestone full of nummulites and other shells into a compact grey limestone, the lower beds of which appear as if made up of rounded masses of the same limestone arranged in horizontal layers and cemented in a calcareous paste. This appearance has probably been produced by the breaking-up of the deposit shortly after its formation, and the subsequent re-cementing of the fragments by the infiltration of calcareous mud.

Both the limestone and the cementing paste abound in nummulites, fragments of Echinidæ, &c. Above, the limestone becomes of a grey argillaceous character, and when bruised, emits a fœtid smell. It gradually passes into blue marls, which are succeeded by an upper deposit of bituminous alum shales Argillaceous limestone beds then follow, of a light grey colour, having a striking resemblance to chalk, and are succeeded by a thick deposit of a very compact light grey limestone, in which irregular shaped masses, and rounded nodules of flint, closely resembling those found in chalk, are abundant. They are particularly so in the district between Numul and the North side of mount Sikesur, and were there collected, in large quantity, by the Sikhs, for the preparation of musket flints. They seem to be arranged generally in layers, and are of a dark grey or black colour, their surface being covered with a white chalky crust, and sometimes with an incrustation of peroxide of iron, which, both in nodules and in small veins, is of frequent occurrence in the limestone. These are, apparently, decomposed pyrites.

The limestone in many places, seems formed entirely of the shells of Foraminiferæ, especially of nummulites which are most apparent in the weathered surface of the rock, a freshly fractured surface often presenting no trace of them.

It is very hard but brittle, and presents a splintery conchoidal fracture. The rock is invariably traversed by deep fissures and cracks indicative of its having suffered severely from the commotions to which the Salt Range has been subjected.

It is a very fine limestone dissolving rapidly in muriatic acid, and with the separation of a small quantity of flocculent silica.

The nummulite limestone formation, west of Pind Dadun

Khan, forms, generally, the top of the escarpment of the range, appearing between that place and Kutha, and in the Chichalee Range, in precipitous cliffs several hundred feet high, which weather of a white colour, and in the distance have a strong resemblance to chalk.

Owing to the rapid disintegration of the shales in the cliffs, the limestone becomes undermined, and huge masses of the rock thus become detached, and strew with their debris the steep sides of the hills. To the north of the escarpment of the range in its central part, the nummulite limestone, in a great degree, conceals the inferior rocks, and is generally distributed over the ridges, table-lands and valleys, which intervene between its north and south sides. Its strata are, however, very much broken up, and in all the deep ravines its relation to the inferior rocks may be observed.

The thickness of the formation varies much, but when well developed, it cannot be less than a thousand feet; in many places it is much more.

In this formation the limestone, as a source of lime, is very valuable, being more generally burned, than any other limestone, in the Salt Range. It is never quarried by the natives, who have only to collect the boulders of it which are strewed in great abundance all along the foot of the hills.

From its brittle splintery character, and the difficulty of obtaining blocks of it, of any size, it is not adapted for a building stone.

The minerals we shall notice as occurring in this formation, are the alum shales as a source of alum, and their enclosed beds of lignite, petroleum and mineral sulphur.

Alum shales are extensively mined at Kalabag, and at Kotkee in the Chichalee pass.* At Kalabag the principal workings are at a place called Chotah, on the north-east side of the Kalabag hill, above the Loon Nula, and about a mile from the Indus, opposite Maree. Here the lower alum shales are fully two hundred feet thick, and are surmounted by a high scarped precipice of nummulite linestone. Regular shafts are sunk in the shale or " Rol" as it is called by the natives, to depths varying from two to three hundred feet. After being carried out of the pits by men and boys, it is packed in coarse blanket bags, and conveyed, on bullocks or donkeys, to the alum works at Kalabag, where the miners are paid at the rate of one rupee for from thirteen to seventeen maunds, according to the quality of the shale delivered. From the incoherent character of the beds, and the rude way of mining them, accidents to the miners are of very frequent occurrence, who, from the sulphureous air they are obliged to breathe in the pits, and the laborious nature of their employment, have a most sickly and emaciated appearance.

In the town of Kalabag there are, generally, from twelve to fourteen kilns for burning the shale, to each of which the necessary arrangements for the preparation of alum are attached. In 1852 only twelve kuras or evaporating pans, were in use, one being attached to each kiln.

In preparing the kiln a layer of brushwood (generally tamarisk jungle which abounds on the banks of the Punjab rivers,) is spread on the ground, to an extent varying according to the size of the one to be constructed. On this a layer of the Rol or Shale in fragments is deposited to the depth of about a foot, to which succeeds a second layer of brushwood, and then another of shale, a quantity of wood being added according as the shale is more or less bituminous. When several of these layers have been arranged, the kiln is set on fire from below, care being taken that the combustion is not too rapid, which, from

time to time, is moderated by sprinkling water on the shales. The kiln being well lighted, fresh layers of shale and brushwood are added, and when the whole has attained the height of thirty or forty feet, it is left to burn, six or eight months being sufficient to effect the thorough decomposition of the mass, which when completed, has changed from a black to a brick, red colour, in consequence of the oxidation of the pyrites. Its surface is covered with an efflorescence of alum containing a large proportion of sulphate of iron or green vitriol, derived from the mutual reaction of the clay and iron pyrites in the shales, which from containing thin films of coal, are admirably adapted for alum manufacture. Close to the kiln, and on a level, a little below its base, there is a baked clay vat, 12 feet square by 1½ feet deep. Into this a portion of the burnt shale is thrown and treated, for several hours, with water, which rapidly acquires a dark brown colour. When a saturated solution of the soluble matter in the shale is obtained, it is drawn off from the vat by an aperture in its side, (which, during the lixiviation of the shale, is stopped by a plug,) into another vat of similar size, but on a lower level. Here the crude alum liquor is allowed to deposit any mud which it may contain, and is then run off into a third but smaller vat, on a still lower level, when it is again allowed to deposit any remaining impurity. From this it is transferred into an iron evaporating pan or "Kura," where it is rapidly boiled and mixed with a brownish impure salt called "Jumsau," from which it derives the alkali necessary to convert the crude alum into an alum of commerce. When a proper quantity of this has been added, which is judged of from the appearance of the liquid, the whole is allowed to settle, and the clear brown alum solution removed into vats, about 9 feet long, 5½ broad, and about 1½ feet deep, a series of which are arranged beneath a shed close to the evaporating pan. In these the solution, which is concentrated to a point a little short of that of crystallization, is allowed, slowly, to crystallize for several days. During that time small alum crystals

are formed of a slightly pink colour, derived from the impure mother liquor which contains a quantity of chloride and sulphate of iron. When a considerable crop of alum has separated, the crystals are removed from the vat, slightly washed with cold water, on a sirkee frame, and allowed to dry. These are afterwards fused in an iron pan, in their own water of crystallization, and when in a fluid state, are removed into large conical earthen jars, one foot eight inches deep, the same breadth at the shoulder, and six inches wide at the mouth, where, for eight or ten days, the alum is allowed to crystallize. At the end of this period a hole is made in the mass of alum, which is generally hollow in its interior, the gura inverted, and the uncrystallized alum liquor allowed to escape. The gura is then broken, and the alum, moulded to its form, is ready for sale and exportation.

The following is an estimate of the expence at Kalabag, per diem, of keeping one kura or evaporating pan, &c. at work. Payments are made in a 13-ana rupee for the Company's maund :—

40 maunds of shale,.................Rs.	3	0	0
Wood to burn this and evaporate the alum liquor, ...	4	8	0
5 maunds of Jumsau, ...	3	0	0
7 Coolies,............................	1	4	0
Sundries,.............................	0	8	0
Water-fee paid to Mulik Oola Yar Khan,	0	1	6
Fee to Mulik of Kalabag, ...	0	4	0
Rupees,	12	9	6
Difference between 13-ana rupee and Co.'s Rs., in Rs. 12-9	2	5	0
Total Expence, Co.'s Rs.	10	4	6

The above expenditure yields a return of three maunds and ten seers of alum, the value of which at Rs. 3-4 per maund, is Co.'s Rs. 10-9. Assuming the above to be correct, (and we give it exactly as stated to us,) the owner of each kura will only have a clear gain of anas 0-4-6 per diem. At Kalabag, however, as the Mulik of the place, Oola Yar Khan, is sole proprietor of five out of the twelve kuras at work, and as he generally pays his workmen and miners in flour, clothes, &c., instead of in cash, his profits are doubtless considerable. He moreover levies a tax of Rs. 2 on every camel load of alum removed from Kalabag.

Alum is manufactured, at Kalabag, for ten months in the year, and about 12,000 maunds (8,571 cwts.) is annually prepared, which, at Co.'s Rs. 3-4 per maund, will yield a return on the spot of Rs. 39,000.

At the Kotkee alum works in the Chichalee pass, the expenses are considerably less, and the alum prepared, though of equally good quality, is sold at the rate of Rs. 2-8 per maund.

They are owned by a Joint Stock Company of eight members, who are chiefly residents of Eesa Khel, on the Indus. Annexed is the expenditure for one kura per diem, of which there are eight:—

60 maunds of shale,..................	Rs.	1	0	0
Wood to burn this and evaporate the alum liquor,..............................		4	0	0
3 maunds of Jumsau,........................		2	8	0
9 Coolies' wages,..............................		1	12	0
Fee for right to water taken by the Lumberdar of Eesa Khel,....................		0	6	0

Sundry expenses, ...	1	0	0
Rupees,	10	10	0
Difference between 13-ana rupee and Co.'s Rs., in Rs. 10-10, ...	2	0	0
Total Expence, Co.'s Rs.	8	10	0

From the above 4 Co.'s maunds of alum are produced, the value, of which at Rs. 2-8 per Co.'s maund, would be Rs. 10, which gives a clear profit, to each kura per diem, of Co.'s Rs. 1-6. About 10,000 maunds are annually prepared.

The Kotkee alum works are, we believe, of recent origin, as compared to those of Kalabag, where the manufacture has been carried on in the same way by Mulik Oola Yar Khan's ancestors, for eight or nine generations. Between the owners of the new and old alum works, there is considerable jealousy: and as the former can obtain the materials for the manufacture at a cheaper rate, they are likely to damage the monopoly that formerly existed at Kalabag, in the days when the Mulik of the place was looked upon as a petty king. It has been already stated, that the substance from which the alkali of the alum is derived, is a brown salt, called "Jumsau," which occurs as an efflorescence on the jungle soil of the plains which skirt the Salt Range and Chichalee Hills, and, indeed, is of common occurrence in all grass jungles and waste grounds throughout the Punjab. It is called "Kulur" by the natives, and from it "Jumsau" is obtained by treating the former with water and drying up its filtered solution, in shallow earthen vessels exposed to the sun. This, on analysis, proves to be a mixture of sulphate of soda with common salt, with varying proportions of carbonate of soda, its quality depending chiefly on the amount of sulphate of soda which it yields.

In all the commercial European alums, as far as we can ascertain, the alkaline base is potash or ammonia, the former alkali being characteristic of British alums, while the latter occurs in those of France. In the alum of Kalabag, however, soda forms the alkaline base, a fact which the addition of "Jumsau" to the crude alum liquor, first led us to suspect, and which an analysis of the alum subsequently confirmed. A soda alum has hitherto, we believe, been known only as an interesting chemical preparation, but previous to 1848, we are not aware that it had been noticed as a staple article of commerce in the N. W. Provinces of British India.

Considering the coarse apparatus in which it is prepared, its purity is astonishing. It effloresces considerably, on exposure to the air, and has a slight pink colour, arising from the presence of a little iron which strikes a blue colour with yellow prussiate of potassa, and only contains a trace of muriate of soda. Although alum is only manufactured Trans-Indus, alum works might, we believe, be established, with advantage, in the Bukh ravine between Mosa Khail and Numul, as there the alum shales are of considerable thickness, and wood and water could be obtained in abundance. In other parts of the Salt Range, the alum shales are too inaccessible, and their thickness too small to be profitably worked as a source of alum.

Lignite or Salt Range Coal.

Throughout the Salt Range from Jelalpoor to the Indus, and in the Chichalee Range, irregular seams of lignite, having, in many places, the aspect of good bituminous coal, may be observed imbedded in the lower alum shales. Lignite also occurs in the upper shales, but in too thin films to be of any use as a fuel.

We shall notice the different localities where we have observed the lignite deposit, proceeding from east to west.

Baganwala.—This coal locality was first brought to the notice of Sir Henry Lawrence,* by Lieutenant Robinson, Bengal Engineers, who forwarded samples of it to Lahor in the autumn of 1847. From these we made an analysis, the results of which, along with a few remarks on the general characters of the coal, were laid before the Asiatic Society of Bengal, in February, 1848.

Baganwala is a small village on the south side of the Salt Range, about ten miles west of Jelalpoor, and about eight miles from the right bank of the Jelum. The coal seam occurs in a ravine about three miles north-east of the village among the hills, and at an elevation of about one thousand feet above the plain. The access to it is by a narrow path, rather difficult and steep, but over which bullocks can travel, if moderately loaded. The nummulite limestone at this point, rests on the upper red sandstone formation, and a burnt claystone, passing into a baked white quartzose sandstone of a few inches in thickness, marks the base of the deposit. Beds of greenish yellow marl, about a foot thick, follow, which gradually pass into sandy bituminous shales, eighteen feet thick, inclosing the lignite seam, on which rests a grey nummulite limestone, seventy-five feet thick, the lower strata of which are marly, of a yellow colour, and full of shells of a species of Ostrea and nummulites. On this limestone a thick series of miocene grey sandstone grits, and red clays reposes conformably, all the strata dipping to the N. N. W. at an angle of from 40 to 45.° (See section No. 5.)

The coal seam, though it may be traced on either side of the ravine, where the above section was taken, for about a mile, does not present an uniform thickness as exposed on its out-crop. On digging into the seam, to the depth of several feet, we obtained about three feet of good coal, and about two feet of coal alternating with films of sandy shale, which latter,

in many places, seems developed, at the expense of the coal which is extremely brittle, so much so that fully one-eighth falls to powder in extracting it. It loses this character, however, to some extent, on digging into the seam, but we fear at whatever depth it might be mined, it never would have the solidity of genuine coal.

In a few hours two or three coolies turned out eight or ten maunds of fair coal, which bore carriage on bullocks over the hills to Baganwala pretty well; a camel load of it was subsequently forwarded to Lahor.

That several thousand maunds of a good fuel could be obtained from this locality, at a moderate cost, I entertain no doubt, but the question as to its yielding a supply for any length of time, can only be decided, by sinking an experimental shaft or gallery into the seam from its out-crop, and working along its strike. This we had neither time for, nor the means of, effecting. In sinking such a shaft, considerable annoyance would be experienced, from the amount of debris and the incoherent nature of the overlying strata in the cliffs above the coal. The high inclination too of the beds, and the consequent liability to have any shaft sunk in them, filled with water after heavy rain, are very serious obstacles to working the coal successfully, even supposing the seam preserves a continuous thickness for any distance, which we are very much disposed to doubt.

Should Government determine on making attempts to mine the Salt Range Coal, we strongly recommend, that this locality be fixed on for the purpose, as it is the only one where any hope of success can be offered.

Drengun.—On the north side of this mountain, and to the west of the path, leading from Besharut to Chooa Gunj Alee

Shah, lignite of a similar character and in a similar position, occurs, but from exposure to atmospheric influence, it is soft and crumbles into a brown dust in the hand. In a ravine of most difficult access, about two hundred yards west of the path, highly bituminous shales, about one hundred feet thick, are exposed, dipping under nummulite limestone to the north-north-west, at an angle of 70° ; in these two or three seams of tolerably good coal were found, the thickest of which was only eight inches. On tracing these, however, for any distance, they seemed all to thin out into mere films in the shale.

As the Drengun coal is evidently an extension northwards of the Baganwala seam, a shaft sunk through the nummulite limestone, on the table land of Besharut, would doubtless reach it, but the expense of sinking a shaft through the hard limestone would be very considerable, and would, in all probability, not be repaid by obtaining a supply of coal of any consequence.

Keura.—About a mile north-east of the salt mine village of Keura, near Pind Dadun Khan, and near a tank known under the name of Ruteebun, a mass of nummulite limestone forms a rounded hill in a ravine, at the foot of which bituminous shales occur, from which, in 1848, we obtained specimens of coal, from a seam about two feet thick, resting on blue clay. In 1849, five hundred maunds of coal were mined from this locality, and sent to Jelum for the use of the "*Conqueror*" steamer, in the month of July. This seems quite to have exhausted the supply, as when we lately visited the locality, we could only find nests of lignite in the shales, which was so soft and powdery, that it was impossible to procure even a specimen. The nummulite limestone formation at this point, and indeed all the rocks, are much disturbed, and the mass of nummulite limestone with the shales, is evidently a portion, which has been detached from its con-

nection with the regular bed, and got thrust under some broken-up beds of Devonian sandstone, which may be seen in the hills above, overlying the nummulite limestone.

Pid.—This locality is to the west of the direct path from Keura to Chooa Seydun Shah. The shale beds lie under a cliff of shattered nummulite limestone, due south from the village of Pid, and between that village and Tober. The access to the locality is difficult, and the coal occurs in two seams, the lower one of which is in some places two feet thick, and separated from the upper, which varies from one to three feet, by shales of about a foot in thickness. From extensive spontaneous decomposition which the shales have undergone, the coal is for the most part charred and brittle, and is encrusted with yellow alumimous earth. In some places the shales have been burnt into a white claystone which is blotched occasionally by peroxide of iron. The brown calcareous sandstone too, on which the shales rest, here and there, presents a baked and whitened appearance, resulting from the heat to which it has been subjected during the combustion of the shales.

The coal is of inferior quality to that of Baganwala, though evidently part of the same deposit. As the cliff on which it occurs is covered by so much debris, we were unable to dig any depth into the seam, so as to obtain specimens which had not been subjected to the influence of decomposition. Where the seam crops out, it is at least two thousand feet above the plain, and is in too inaccessible a locality ever to be worked to advantage. By mistake in our Report of 1848, we called this coal locality Ruteepind.

Dimdhote.—In a ravine about five hundred yards west of this village, and under the high escarpment of the Salt Range, a mass of nummulite limestone, which has evidently been detached from the escarpment, forms a small rounded hill, at the

foot of which some lignite, in a seam about two feet thick, crops out. As this is only a detached portion of the regular deposit it is of no importance, except as proving the extension of the coal seams along the range.

Mukrach.—We have seen coal under detached masses of nummulite limestone in the hills above the salt-mine village, but the regular shale bed is covered in the escarpment where we examined it, by a great quantity of debris.

Noorpoor.—Under the high cliffs of nummulite limestone below Noorpoor, the shale beds are distinctly seen, much decomposed however, and containing two small seams of coal from eight inches to a foot in thickness. A great amount of debris covers the shales and renders it unsafe to make exploratory diggings.

Kutha.—At the top of the Kurumee Wan, above Kutha, and beneath a high precipice of limestone, dark arenaceous shales full of pyrites occur, and enclose two or three seams of coal of good quality, the thickest of which was not more than half a foot. It has a much more mineralized and compact appearance, than the lignite from most other localities. When we first observed the coal in this locality, in March 1851, the seam could be traced for about thirty yards, dipping to the north-west at an angle of 25° under the nummulite limestone. In January 1852, when we again visited the spot, the out-crop of the coal was completely concealed by enormous masses of the limestone, which had, a few days previously, become detached from the cliffs above, during an earthquake. We merely mention this as illustrative of the difficulties that would attend any attempts to mine the coal, as it occurs generally in the range.

Kotkee, in the Chichalee Pass.—Between Kutha and the Indus, we have seen no coal deserving of notice, though films of

it may be observed in the alum shales of the Bukh ravine and in other localities. In the highly bituminous alum shales which supply the Kotkee alum works, layers of very compact bituminous coal occur, but they seem to be continuous for but a short distance, either thinning out in the shales, or becoming interlaminated with these. From the interior of one of the shale pits, we obtained several specimens of coal, which appeared to form a sort of nest inclosed in the shales, and was being quarried along with them for transmission to the alum kilns. The miners declared to us that the coal never occurred in seams, but merely in patches of irregular extent and thickness. The shale at Kotkee is remarkably fresh, and, except on the surface, is not at all decomposed. It contains more carbonaceous matter than any other shale of the sort we have seen in the nummulite limestone formation, and hence, as but little, wood is required to burn it, when once it is lighted, it is most economically used in the preparation of alum. The pits are sunk to no great depth in the shales which dip under the limestone at an angle of from 30 to 35°. By sinking a shaft to some depth in the shale, it could be easily determined whether the coal occurs here as a seam or not. The locality is a convenient one, and access to the present shale pits easy.

Having thus indicated the existence of coal in seams of irregular thickness throughout the nummulite limestone formation, for a distance of one hundred and thirty miles, it is evident that a very considerable amount of fuel exists; but the very irregular thickness of the deposit, the high angle at which the strata dip, their inaccessible position, and the immense amount of debris in the cliffs above the coal, will, we believe, prove serious obstacles to mining it successfully as a steamer fuel. A few experiments conducted in the more favourable localities can alone decide the point.

Wherever the coal has been observed, its characters are identical. It is evidently a lignite or brown coal, as it gives a brown streak, and frequently contains half-decomposed patches of brown carbonaceous matter resembling peat. Specimens of the coal obtained from some depth, and which have not suffered from atmospheric influence, are highly bituminous, of a glistening black colour like jet or cannel coal, and sometimes present a pavonine lustre. It is very brittle, a character peculiar to all lignites or recent coals, small crystals of gypsum may generally be observed in the coal, which, in most localities, contains but little of the iron pyrites, so abundant in the alum shales. The origin of the coal is probably marine, and from the abundance of large gasteropodous molluscæ in the strata, both above and below the shales, it is probable, that by their decomposition, as well as that of fuci and other marine vegetables, the coal has been formed. No indications of fossil-wood or remains of land-plants have been detected in the shales, from which, however, we have procured one or two shells of the genus Cerithium or some allied genus. The surface of the shales is sometimes encrusted with an efflorescence of sulphate of magnesia.

The coal is somewhat difficult to ignite, and at first emits a large quantity of smoke which has a strong empyreumatic odour. When combustion, however, is once established, it burns without coking, gives out a considerable amount of flame and heat, and leaves a brown ash, the quantity of which varies considerably in different specimens.

We annex the results of the analysis of two specimens of Baganwala coal, and of the coal from the Kotkee alum-shale pits:—

Baganwala No. 1.

Coke (carbon,)	41.36
Volatile, bituminous inflammable matter,...	40.64
Ashes, ...	18.00
Total, ...	100.00

Baganwala, No. 2.

Coke (carbon,)	59.705
Volatile, bituminous inflammable matter, ...	38.455
Ashes, ...	1.840
Total, ...	100.000

N. B. No. 1, was from the upper part of the seam. No. 2, was from its centre, and was a remarkably fine fresh specimen.

Coal—Kotkee alum-shale pits.

Carbon (coke,)	33.579
Volatile, bituminous inflammable matter,...	36.421
Ashes, ...	30.000
Total, ...	100.000

From the above it will be seen that though inferior to good English coal, that of Baganwala possesses the necessary requisites for a good steamer fuel. The small amount of ash in No. 2 is very remarkable.

From its large amount of ash, the Kotkee coal is of inferior quality, and in burning would yield a quantity of clinker. If it could be got in quantities, it would, however, be valuable, as it

burns freely, notwithstanding the large quantity of earthy matter it contains. Seams of coal, apparently of a very similar character to those in the Salt Range, are described by Sir Roderick Murchison, as associated with nummulite limestone formation, in the Alps and Appenines, in a paper published in the Quarterly Journal of the Geological Society, for 1848. He states that, "in the Beatenberg, near Thun, a band of coal is associated with the nummulitic deposit which is now extensively used in the manufacture of gas, at Berne. Near Val D'Agno, to the south of Pecoaro, seams of coal are worked for use in that neighbourhood which lie in shales which dip away from the older rock, and pass under the adjacent hills of nummulitic limestone. In fact these coal beds occupy the same place as those of Entrevennes in Savoy, of the Diableritz, and of the Beatenberg in the Canton of Berne." We much regret that no particulars are stated in the invaluable paper from which we have quoted, as to the thickness, mode of working, &c., of the coal seams.

Petroleum exudes from the nummulite limestone rock in the Kutawan, near the village of Juba, on the north side of the Salt Range, ten miles east of the Indus. It occurs but in small quantity, and is collected by a method similar to that employed at the petroleum springs of Kafir Kote. It is associated with springs of sulphureous water, the sulphur of which, as well as the petroleum, are probably derived from the destructive distillation of the bituminous shales beneath the nummulitic limestone. It here receives the name of Gunduk-ka-tel (sulphur oil). It is of a dark brown colour, very fluid, and yields, on distillation a good deal of Naphtha.

Besides the numerous springs charged with sulphuretted hydrogen, and which deposit sulphur on the rocks over which they flow, and on the grass and weeds by their sides, sulphur, in a mineral form, occurs near the surface of the nummulite limestone at Juba, a little above the petroleum springs, in a

white porous gypsum, which has evidently been formed by the decomposition of the limestone, 'unaltered portions of it still remaining imbedded in the gypsum.

The metamorphosis has, doubtless, been effected by the action of sulphuretted hydrogen and sulphureous acid. These gases, generated in the decomposing alum shales, by passing through the fissured limestone and porous gypsum which covers its surface, become mutually decomposed, sulphur being deposited. Dumas, in 1846, proved, that when sulphuretted hydrogen, at a temperature above 100 Faht., and still better when near 190°, comes into contact with certain porous bodies, a catalytic action is set up, by which water, sulphuric acid, and sulphur, are produced. In this way sulphur is universally formed in nature, and even in volcanic countries, "no well authenticated case of its sublimation in an uncombined state,"* is known. The thickness of the sulphur formation is very trifling, but may be observed over a space of about two miles along the strike of the limestone.

The sulphur is in small quantity and of a bright yellow colour. It was formerly worked by Maha Raja Goolab Sing, of Kashmeer, who found it unprofitable and removed his establishment to Nakbund, (a most appropriate name for a sulphur manufactory), near Koosalgur, on the right bank of the Indus, between Atok and Kalabag, where it is said, sulphur exists in considerable quantity. The unsettled state of the hill tribes in the Kohat district, prevented our visiting the Nakbund sulphur deposit. We are, however, informed by Misr Geean Chund, the present Teseeldar of Pind Dadun Khan, and former tax-man of the Salt Range salt mines, that during the Sikh rule, he, for three successive years, from the above locality, extracted 1,000 Lahoree maunds of sulphur, for the manufacture of gunpowder for the Sikh army. This he was able to

* Daubeny on Volcanoes, 2nd edition, p. 615.

supply at the rate of Rs. 6 per maund. He described pits of thirty or forty feet in depth, as being dug into the sulphur formation, which he reckoned of considerable extent. The mines are about five miles from the Indus near a village called Rici, and about three miles below Koosalgur.

The mode adopted by the natives for extracting the sulphur from its matrix, is very simple. A hole is dug in the ground on which a large gura or earthen vessel with a wide mouth, is placed. This is then filled with the coarsely powdered rock. A second gura, in the bottom of which a large hole has been made, is then put on the top of the lower one, and secured to it by a luting of clay, to which succeeds a third and a fourth, all communicating with each other. A sharp wood fire is then lighted under the lower gura, by which the sulphur is gradually sublimed in the form of flowers of sulphur into the upper ones, to the sides of which it adheres. The subliming process generally goes on for eight or ten hours, by which time all the sulphur has been expelled from its matrix.

None of the organic remains, which occur in the nummulite limestone formation, have been detected in the rocks inferior to it. The molluscæ which characterize it, have a totally different character, and neither belemnites, ammonites, nor terebratulæ, which occur in the oolitic rocks beneath, are to be seen, their place being taken by swarms of Foraminifera of the genera Nummulina and Fasciolites (?) and by large Gasteropoda of the genera Conus, Trochus, Oliva, Mitra, Voluta, Terebellum, Natica, Neritina, &c.

Several large bivalves also occur, and a small Ostrea (?) forms in some places patches of yellow marly limestone.

The abundance of nummulites is very remarkable; and at least two or three species occur. 'They have, of late years, been considered as characteristic of formations superior to the chalk. and as regards the Alps where the nummulite limestone is so extensively developed, Sir Roderick Murchison, in his paper above quoted, says :—" I am persuaded that no form of the genus Nummulina occurs below the surface of the chalk, or its equivalent;" and again, "that the lowest beds with nummulites are completely above all those rocks which are the equivalent of the white chalk of northern Europe."

Cephalopoda seem very scarce. We have only obtained specimens of two large species of Nautilus.

Radiata are in some places rather plentiful, and specimens of species of the genera Spatangus, Galerites, and Clypeaster have been procured; some of the former are of large size.

The only indication of vertebrata we have obtained, are a few teeth, evidently those of sharks, and one or two small fragments of bone, too indistinct, however, we fear, to be identified.

The fossils, except in the calcareous sandstone, are generally ill-preserved. In the limestone they are generally mere casts of shells, and those obtained were generally much weathered.

In superficial extent, the nummulite limestone formation covers a larger space in the Salt Range, than any of the rocks hitherto described. In the eastern part of the Range it is first observed on the northern flank of mount Tila, a little above the village of Bhet, as a band of yellow marly shell limestone, not more than twenty feet in thickness, resting on upper Devonian red shales, and covered by thick beds of Miocene (?) strata

Preserving the same relations, it may again be seen at Jelalpoor, on the North side of the Range, and from thence may be traced, uninterruptedly, to Baganwala, where it has a thickness of from seventy-five to eighty feet.

West of this it seems, rapidly, to increase in thickness and from the top of the Range, where it crops out in the escarpment, it stretches north in nearly horizontal strata, forming the table-land of Besharut. Here it skirts the flank of mountains Kuringulee and Drengun, the ridges of which, formed of Devonian rocks, have been forced up through the nummulite limestone, and throw it off with an anticlinal dip from either side. On the west end of mount Drengun, it entirely conceals the Devonian rocks, and from thence dips north under the narrow valley which separates mount Drengun from Deljuba. In this valley it is covered up by Miocene strata, but on the north side of the Deljuba ridge, again crops out dipping to the south-east under the Miocene strata at a high angle. At the west end of the escarpment, on the north side of Deljuba, it appears resting on the Devonian rocks, but on proceeding eastward it seems to thin out, and to be covered over by the Miocene strata. The limestone can, however, be traced projecting here and there through the latter, on to the Ghorigula Pass, where it appears in a nearly vertical wall, some thirty feet thick, crossing the pass from south-west to north-east, and gradually disappearing under the Miocene strata, which are thrown off from it, from either side of an anticlinal axis.

We are not aware that the limestone is anywhere seen, between the Ghorigula Pass and Bukrala.

From the neighbourhood of mountains Kuringalee and Drengun, the nummulite limestone stretches westward, and forms the superficial rock in great part of the central district of the Salt Range. As far west as Noorpoor, it is in relation with Devonian

rocks; but between this and Koofree, the carboniferous rocks intervene. In this neighbourhood the Oolitic rocks appear at the base of the Eocene formation, and as we proceed westward, separate it more and more widely from its eastern associates.

At the west end of the Sone Sikesur valley, all the strata forming the high ridge of mount Sikesur are tilted up at a high angle. Along the foot of its scarped or S. S. E. side all the rocks are very much disturbed, but in the escarpment itself great regularity prevails, the nummulite limestone forming its summit, and N. N. W. side till near its base, where it is covered up by conformable Miocene sandstones, &c.

From mount Sikesur on to within two miles of the Indus, the nummulite limestone occurs uninterruptedly; but though of greater real thickness than to the eastward, makes comparatively little show, owing to the high angle (45 to 50°) at which it dips to the north-east under the Miocene rocks.

In the disturbance which the strata in the neighbourhood of Maree have undergone, the nummulite limestone seems to have been entirely removed, but on crossing the Indus to the Kalabag hill, beds of it again appear.

These stretch round into the Chichalee Range, and, as seen in the Chichalee Pass, have a thickness of upwards of one thousand and three hundred feet. In this Range, as in the Salt Range, the nummulite limestone appears in bold white cliffs, forming the summit of its scarped or south-east side, and the formation may be traced down to within six miles of the Koorum river, where it thins out under Miocene sandstone.

It does not appear in the upper part of the Kafir Kote Range, though, from the researches of Captain Vicary, it is known to occur to a considerable extent in the southern part

of the Sooleeman and Hala ranges. Capt. Grant, too, in Kuch, has described a series of beds of nummulite formation extending over a space of about thirty miles, many of the fossils obtained from which are identified with those we have found in the Salt Range.

During the hot weather of 1851, we detected nummulite limestone of a very different appearance from that of the Salt Range, as forming the surface rock, at least of several of the Hazara hills north of Rawul Pindee, and on the mount Mochpoor. About fifteen miles north of the new Muree Sanatarium, which attains an elevation of upwards of nine thousand and seven hundred feet, we obtained abundance of nummulite limestone on its sides and summit.

From Kashmeer too, Mr. Vigne obtained limestone containing nummulites. This we have seen in situ on the side of a mountain at the upper end of the Manasabul lake, where it is much disturbed and calcined by greenstone. It probably forms the summit of many of the higher hills on the northern side of the Kashmeer valley, a district fraught with interest to the Geologist, and hitherto quite unexplored.

When we consider that the nummulite formation may be traced from the Mediterranean, through Egypt, Asia Minor, and Persia, into the north-west and southern provinces of British India, and throughout all this extent preserves the same zoological character, though differing considerably in mineral aspect, the importance attaching "to a right understanding of its true position in the Geological series," cannot be overrated.*

* Since writing the above, we have had the pleasure of perusing the anniversary address, for 1852, of the President* of the Royal Geographical Society, in

* Sir Roderick Impey Murchison.

Tertiary, Miocene (?) Rocks, greenish Sandstones, argillaceous Grits, Conglomerates, and red and green Clays.

Resting on the nummulite limestone, there is observed, throughout the Salt Range, a conglomerate of small rounded boulders of a similar limestone, connected by calcareous sandstone. This passes into a series of soft greenish sandstones, alternating with bands of conglomerate, in which small boulders of plutonic and metamorphic rocks predominate. These bands are very numerous near the Indus, above Kalabag, where among the boulders a black porphyry (melaphyre) is very abundant. Along with the sandstones and conglomerates, beds of argillaceous grit and red and green clays, occur, which contain crystals of selenite and small veins of carbonate of lime and quartz.

The sandstones are highly calcareous, effervesce strongly when treated with muriatic acid, which, after dissolving the calcareous matter, leaves a sand chiefly composed of quartz, felspar,

which it is stated, on the authority of professor Oldham, that " the coal and iron of the district of Cheera Punjee, or the range of hills which separates Asam and the Berampooter from the plains of Sylhet, belong to the nummulite tertiary formation." We may also state that from specimens of the coal and rocks connected with it, which were forwarded for our inspection, from the Singrowlee coal mines near Meerzapore, in December, 1849, by Claude Hamilton, Esq. one of the proprietors, we gave our opinion that it was a coal of a similar character and of a similar age, with that of the nummulitic formation of the Salt Range. This coal is now pretty extensively consumed by the Ganges Steamers, and is sold, at Meerzapore, at the rate of 75 Rs. per hundred maunds. A sample of this coal which we analyzed in September 1850, gave the following results :—

Carbon (coke,)	43.34
Volatile, bituminous inflammable matter,...............	50.00
Ashes, ...	6.66
Total, ...	100.00

hornblende. mica and magnetic iron. In the neighbourhood of the nummulite limestone, their surface is frequently encrusted with a slight saline efflorescence, but this disappears in the upper beds.

Where exposed to atmospheric influence and to the action of water charged with carbonic acid, the. sandstones are extremely soft and incoherent, but at some depth from the surface, many of the strata are hard and compact, and of a dark grey colour.

The thickness of the above strata is enormous, and cannot, we should think,be less than ten thousand feet, having, wherever seen, a remarkable uniformity of character. Fragmentary portions of the bones of large mammalia, &c. are, everywhere, to be found associated with silicified wood of a brown colour. These are most abundant in the argillaceous grits which are often so hard as to form excellent millstones.

The harder beds of grey sandstone yield a remarkably handsome building stone, though, by no means, likely to be a durable one, in many localities, on accouut of the facility with which water charged with carbonic acid, removes its calcareous cement, and reduces it to the strata of a slightly indurated sand. It has, we believe, been used extensively in the construction of the various works along the new Peshawur road, west of the Bukrala Pass, where fresh beds have been exposed in the deep cuttings which have been made through the sandstones and clays, which form entirely the Bukrala Range.

Gold is found, in this formation, in the shape of minute scales diffused through the sandstones, and has doubtless been derived from plutonic and metamorphic rocks, the disintegration of which has furnished the material of which the strata of the series are composed.

In the beds of the numerous nulas or water-courses which flow through the Miocene district, the sand is washed, pretty extensively, for gold, by the natives. It seems to be obtained in greatest quantity towards the Indus, north of the Salt Range.

As compared with the gold fields of Australia and California, the auriferous beds of the Punjab are, as far as is yet known, in a practical point of view, insignificant; but are nevertheless interesting, as illustrative of the extensive diffusion of gold in debris over the globe.

We have been quite unable to trace the source from whence the gold has been derived, and are not aware that, among the quartzites and quartzose mica-slates, which are much developed in the Punjal Range, near the Baramula Pass into Kashmeer, and stretch west into the northern Hazara mountains, the metal has ever been detected in situ. From similar rocks, there can be little doubt that the auriferous sands have been derived; but the Himalayas must, at the period of their formation, have had a very different aspect from what they now present, and may not have been elevated at all above the general level of the country.

The mode of obtaining the gold is, we fancy, nearly the same as that adopted in other countries.

A part of the bed of a nula or water-course, or dry channel of a river, having been fixed upon as a likely spot, the superficial stratum of sand and mud is removed, and that beneath collected with a wooden shovel, and carried to the spot where it is to be washed, generally close at hand. The washing is effected in a long wooden box, resembling a small shallow flat-bottomed, boat, wide at one end, and narrow at the other, where there is an opening for the escape of the water. The wide end of the "cradle", or troon as it is called, is slightly elevated, so as to give its flat bottom a gentle inclination towards its fore-part

and a coarse sieve of reeds is then placed across the wide end of the box. On this the sand is thrown, and water dashed upon it, by which means the finer sand is washed into the cradle, the coarser gravel being retained on the sieve. By continuing the washing with a gentle stream of water, the lighter particles of the sand are carried down the inclined floor of the cradle and escape with the water, while the heavier and auriferous sand assumes the highest level next to the point where the water is applied. In a very short time, nothing remains on the floor of the cradle, but a thin stratum of black iron sand in which the scales of gold may occasionally be seen to spangle. By continuing the washing of the sand, the lighter particles are removed, and the auriferous portion concentrated within narrow limits. When the washing, in the cradle, has been carried as far as is considered safe, the sand is removed by the hand into a circular concave wooden platter, called a Kutree, about two feet in diameter, made generally of sisoo (*Dalbergia Sisoo,*) or other hard wood. In this, by a circular motion, it is agitated with water, by which means an additional portion of the black sand is got rid of, and washed away, from the inclined sides of the platter, by a stream of water skilfully applied. The residue is then rubbed up with a little mercury, which quickly, by amalgamation, separates the gold from the black sand. The mercury is then removed from the platter, enclosed in a fragment of cloth and placed on a bit of live charcoal, by which means the mercury is speedily vapourized, leaving the yellow gold entangled with the tinder of the cloth, from which by rubbing, it is easily removed. In this state it is taken to the goldsmiths, who by fusing it with borax, remove any mechanical impurities. The Indus gold is said to have a whiter colour than that obtained to the eastward, which probably results from its containing a small portion, of silver alloy.

By the process above described, a party of two or three individuals can, in one day, collect from six to eight anas' worth

of gold. The washings are generally most productive after rains, during which, of course, large quantities of fresh sand are washed from the surrounding rocks with the nulas.

In the neighbourhood of the Salt Range, the scales of gold are small and almost invisible, but we have heard from natives, that in Hazara, grains of gold are sometimes found of a size such as to admit of their being picked out of the sand. If this be true, we may infer that the auriferous source is somewhere to the north, and that by tracing the gold stream, so to speak, we might arrive at a point where the drifted materials become coarser, and where the gold, from its high specific gravity, has been deposited in larger quantity.

By a similar method of reasoning, Messrs. Clarke and Hargreaves, in 1851, were led to the discovery of the extensive gold fields in the alluvial deposits of the Bathurst district, in Australia, where the amount of gold obtained seems likely to produce an entire revolution in the monetary system of the world.

From the similarity of the central hilly districts of the gold fields of Australia, with the auriferous districts of the Ural mountains, Sir Roderick Murchison, so early as the year 1844, predicted the existence of gold fields, " and in 1846 he addressed the President of the Geological Society of Cornwall, on the subject and recommended any Cornish tin-miners who were unemployed, to emigrate to New South Wales, and dig for gold in the debris and drift, on the flanks of what he had previously termed, the Australian Cordilleras, in which he had recently heard, that gold had been discovered in small quantities." Had the British Government then attended to the suggestions of science, much of the evil resulting from the recent announcement of the abundance of gold, might have been prevented by the timely introduction of suitable regulations for its mining.

Gold, wherever it has been noticed in veins, is found in greatest quantity near their surface, "which accounts for the existence of the metal in such abundance" in the debris of auriferous rocks, "the same agencies which deposited the drifted materials having also carried away the gold from the superficial portions of the veins in which it was originally formed."

In the sandstones and grits, but especially in the latter, bones, teeth, &c. occur. The bones seem chiefly to be the remains of large mammalia, and are of a grey or a light brown colour. They are generally fragmentary, and are much rubbed, as if they had been transported from a distance. Associated with them, we have found portions of the teeth of a species of mastodon and of a mammoth or elephant, the tusks of which, of enormous size, are occasionally found imbedded in the sandstone. We have also procured the core of the horn of a species of deer, and teeth, probably of a camel, or nearly allied animal, besides several large saurian teeth and one large and curved tooth, probably that of some large carnivorous animal; a portion of the Carapace of a Chelonian was also found. The fossils nowhere occur in great abundance, but are every where found in the miocene strata between the Jelum and the Indus.

The only examples of molluscæ which have been detected, in connection with the above remains, consist of three specimens of probably a species of Unio or Anadonta. These where found in the soft sandstones on the southern side of mount Tila, near the village of Hoon, by my Assistant, Mr. Theobald.

The fossil wood formerly alluded to, as occurring throughout the strata, is evidently of endogenous structure, and many of the masses appear to have belonged to trees of large size. At Kular Kuhar, in soft sandstone strata north of the salt lake, patches of jet occur in small quantity, which are probably carbonized portions of wood, but in these the woody structure is in a great degree obliterated.

From both the mineral and zoological character of the tertiary strata, which we have just described, there can be little doubt that they are merely the western extension of the strata of the Sivalik Range, which, in the annals of geology have been rendered famous by the researches of Cautley and Falconer. These strata flank the great Himalaya Range, and from the Sutlej, we believe, may be traced along the north-eastward or hilly districts of the Punjab to the neighbour hood of the Jelum, where they form a succession of ranges, preserving a general parallelism, running in a S. S. E. direc tion towards the plains, from the flank of the Punjal Range.

On the left bank of the Jelum, opp osite the town, they form the Khoreean range, and lower down stretch across the river into the Surafar hills, which flank the east side of the Chumbal range, between Tila and Jelalpoor. In the neighbourhood of this range, the miocene strata dip to the east at an angle of 70°, the dip gradually decreasing, as we proceed eastwards towards the Jelum. They extend along the bank of the river to Jelalpoor where, in nearly vertical strata on which the town is built, they appear at the foot of the southern escarpm ent of the Salt Range, having evidently been formed into this position by the upheaval of the older rocks. About half a mi le west of Jelalpoor, the sandstones disappear, and no miocene strata are again seen on the south side of the range east of the Indus.

Proceeding westward, from Jelum, along the Peshawur road, the miocene strata appear about four miles from Rhotas, rising out of the plain at a high angle, with a dip to the east, and form the Rhotas range, which, from the right bank of the Jelum, stretches south-west to Mount Tila. By the upheaval, however, of the older strata of that mountain, an extensive fault has been produced, by which the tertiaries in the immediate neighbourhood of its southern escarpment, have been made to dip north, and, as it were, under the Devonian strata. Between Rhotas

and Tila, the miocene beds are elevated into an anticlinal ridge, on the north side of which the strata dip westward towards Bukrala, where they are elevated into another parallel range to that of Rhotas. Beyond this they extend, uninterruptedly, to Rawul Pindee, presenting a series of anticlinal and synclinal axis.

From the Tila and Bukrala ranges the miocene strata extend along the north side of the Salt Range, elevated into scarped ridges with a dip at a considerable angle, to the north, which gradually diminishes as we recede from the Range.

In its central part, where the nummulite limestone strata are in many places in a nearly horizontal position, patches of miocene sandstones, &c. occur, but from the facility with which they decompose, are rapidly undergoing this disintegration on the surface of the limestone. Along the north side of mount Sikesur and on to the Indus, the tertiaries are elevated along with the inferior rocks, and at Numul, above Moosa Khel, may be seen dipping conformably with them (as is the case everywhere else,) at an angle of from 50° to 60°.

Above Maree on the Indus, they form barren hills of considerable height, which extend along the river up to Mokhud, a distance of about sixteen miles. On its right bank they attain a greater height, and the summit of the well-known scarped precipice of Dinghote, about two miles above Maree, at the foot of which the Indus flows, is, as ascertained by the Thermometer, 2,113 feet above the Indus at Maree. Looking north from its summit ; the horizontal ridges of miocene strata can be seen as far as the eye can reach, crossing the Indus from N. N. W. to S. S. E., with a dip to E. N. E. At Maree the angle of dip is 35°, but this diminishes as we ascend the Indus. On the Kalabag hill the miocene strata have suffered great disturbance, and rest in some places on the salt marl. At this point there is a great amount of nummulite limestone conglo-

merate, at the base of the formation. Along the north side of the hill it appears in normal order, resting on the nummulite limestone, and preserving this relation, stretches round into the Chichalee Range. On its west side the miocene strata are arranged in regular ridges forming the Chountera hills, and in the Chichalee Pass, dip with nummulite limestone to the north, at an angle of 35°. From this to the Kafir Kote they occur uninterruptedly, and there rest, conformably, on the carboniferous rocks, dipping to the north-west under the Punkala Pass, on the west side of which they are elevated into a high ridge which runs parallel to that of Kafir Kote.

Along the east side of the Chichalee Range, the same miocene sandstones, &c. occur, as on the west side, but much disturbed and evidently overturned in some places, during the upheaval of the range, which has thrown them under strata of the older rocks, also overturned along with them, on which in a normal order, they invariably repose.

Captain Strachey, in a paper recently laid before the Geological Society, has described a series of tertiary ossiferous sandstones, &c., which occur on the Thibet plain, on the north side of the Himalayas, at an elevation of from 14 to 16,000 feet, which, most probably, are of an identical character with those of the Sivalik and Salt Ranges. These, he describes, however, as "presenting an almost perfectly horizontal surface," and resting unconformably on oolitic strata, (apparently similar to those of the Salt Range), from whence he draws the conclusion, that the oolitic strata, &c., on which the ossiferous tertiaries rest, have been elevated previous to the formation of the latter; but from the abundance of remains of large mammalia in these, he considers that "there can be no doubt that these strata have been elevated to their present height from some lower level since the time of their deposition."

In the Salt Range, we think, we have obtained sufficient proof, that until after the deposition of the miocene sandstones, &c., no sudden or extensive elevatory action had been exerted, and that during their formation, the surrounding country must have been in a condition suitable for the maintenance of numerous huge mammalia, the remains of which, now entombed in rock, must, judging from their appearance, have been transported to a distance from the spot where they died.

That plutonic, metamorphic and igneous rocks must have formed the district, by the disintegration of which the materials forming the miocene strata have been derived, every one must admit; and as the boulders found in the conglomerates are small, and such as we see now carried down by streams from Indian mountains during ordinary floods, we think it probable, that the district in which the miocene beds occur, must have presented a range of mountains, skirted at their base, by a grove of forest, capable of affording food to large pachydermata, and washed by an extensive fresh-water lake, in which the saurians, &c., whose teeth occur in the sandstone, could live and flourish. Into this, floods from the surrounding mountains transport boulders of rock, gravel, and sand, as well as the remains of land animals and trunks of trees. A succession of floods over an extended period would, we conceive, supply material for the formation of strata similar to the miocene beds we are considering.

It is not at all improbable that the sea may have had occasional access to our supposed lake, indeed the saline incrustation on the sandstones, &c., where they approach the nummulite limestone (an undoubted marine formation,) strengthens this idea.

The absence, however, of marine shells, or other remains which exist so abundantly in the inferior strata, completely, we conceive, refutes the supposition that the miocene strata have

been deposited in "a true sea bottom," an opinion, which, as regards the Thibet tertiaries, in which no marine organic remains have been found, Strachey seems disposed to adopt, while at the same time he admits "that there is no direct proof that these beds are marine."

When we consider the fragile character, and we believe comparative scarcity, in northern India, of land or fresh-water shells, it is not surprising that they should so seldom occur in the miocene strata. The Physæ, Pupæ, and Helices, which abound over the Salt Range hills, are very rarely to be found in the alluvial deposits at their base, and the fact that rain water, charged with carbonic acid, which it always acquires by passing through vegetation, is a most powerful solvent of carbonate of lime, may explain, in a great measure, the scarcity of land-shells. The rarity of the common land-shells of the Punjab in the high alluvial banks seen on the sides of the rivers, has often struck us as very remarkable.

Should the beds described by Strachey be proved, hereafter, to be identical with those on the southern flank of the Himalaya or Sivalik strata, it will go far to prove that this stupendous range has been upheaved from near the level of the sea to its present altitude at a comparatively recent period.

From a cursory examination of the ranges of hills between Rawul Pindee and the Baramula Pass, we are inclined to believe, that from the former place to Ooree on the Kashmeer river, nothing but miocene strata occur, forming ranges of from 4 to 8,000 feet in height. At Ooree the metamorphic schist of the Punjal Range, seems to have been forced through the sandstone strata, both being, at this point, tilted up into a nearly vertical position with a strike from east to west. Hard specimens of sandstone from this locality are undistinguishable from the hard grey miocene sandstone of the Salt Range. Between the Jelum and

Kashmeer river, in a line from Ooree to Rawul Pindee, we have never observed any organic remains, but towards Beembur to the eastward of Ooree, we believe, they are occasionally found, and are called by the natives "deo ka dant," or Demon's teeth, a name by which they are generally known in the Salt Range.

In reckoning as miocene, the sandstone grits and conglomerates we have endeavoured to describe, we only follow the generally-received opinion as to the age of the Sivalik strata. Further investigation may prove that these, as well as the corresponding strata west of the Sutlej, are of even more recent formation.

The occurrence of gold in the formation, furnishes an argument in favour of its being of post tertiary age, this metal and platinum being considered "the last formed of the metals" by the learned author of the article entitled 'Siberia and California in No. 174, (September 1850,) of the Quarterly Review.

Post pliocene strata.

ALLUVIUM.

Resting on the miocene strata in an unconformable manner, may be noticed, in many places along the north side especially of the Salt Range, terraces composed of a succession of nearly horizontal layers of small boulders, gravel, sand, and mud, the debris chiefly of Salt Range rocks. The boulders and gravel in these are very generally cemented, by calcareous matter, into the consistence of rock, and bands of kunkur, an impure concretionary limestone, are in some places abundant. This has doubtless been deposited by calcareous springs or by rain water, which by passing through vegetation, has acquired carbonic acid, and, through its solvent agency, carbonate of lime. In a similar way, extensive

deposits of travertine and calcareous tufa, have been formed over the surface of the nummulite limestone and miocene strata.

In the neighbourhood of the Salt Range the alluvial beds have a slight dip towards the north, but gradually acquire horizontality, and increase in thickness and fineness of material, as we follow them into the plain, or rather ravine country, north of the range, where sections of them, fifty to sixty feet in depth, are exposed in the numerous nulas and water-courses which intersect the district, and in the beds of which they are seen reposing on the tilted-up ends of the miocene strata.

Along the southern or scarped side of the range, deposits of a similar character occur, but for a distance, varying from one to two miles from its base, the materials are coarse, and consist entirely of boulders of rock and gravel brought down by the numerous streams, which, during rain acquire transporting powers which must be seen to be believed; we have, on several occasions, seen boulders three and four feet in diameter, rolled along with the noise of thunder, by the force of streams suddenly swollen. As we recede from the range, the boulders gradually diminish, and are succeeded by deposits of gravel, sand, and mud, the layers of which, in the plain, assume a nearly horizontal position.

Travertine or calcareous tufa is extensively burnt and yields a lime of excellent quality. It frequently, however, contains a quantity of mud, which is objectionable. At Jelum the greater part of the lime used is obtained from travertine, and at Rawul Pindee, around which enormous deposits of it occur, we believe it is exclusively burnt. From its porous character, it requires less fuel for its perfect calcination than the ordinary limestones of the district, a matter of some importance, when wood is scarce. Kunkur, used extensively, for the metalling of roads, is abundant every where in the alluvial deposit. Irregular beds of it occur in the neighbourhood of Jelum.

The organic remains found in the alluvial formation, appear to be entirely of a recent character, and to consist of the bones of bullocks, horses, camels, goats, &c. mixed with a few land shells of the genera Physa, Pupa, &c. The extreme scarcity of the bones is very remarkable, considering the number of bones and skeletons every where seen lying on the surface.

We are not aware that the remains of any large pachydermata have been found associated with the above bones.

As the alluvial strata north of the Salt Range, are apparently formed from the debris of the tertiary strata, "gold dust" must occur in these, and, during rain, must be washed into various streams and water-courses. The immense number of boulders of Plutonic, Volcanic, and Schistose rocks which occur in the alluvium or drift in the neighbourhood of Mokhud on the Indus, (though identical with those in the miocene conglomerates), may possibly, in part, be derived from other rocks to the northward which may contain gold. The black slate rocks of Atok, if metamorphic or of Lower Silurian or Cambrian age, (we have never visited the locality,) and invaded by quartz veins, may probably yield gold. Boulders of slate rock, similar to band specimens we possess from Atok, occur abundantly both in the auriferous miocene (?) as well as drift or alluvial strata between Kalabag and Mokhud. As illustrating the statistics of gold in the Punjab, we may add, on the authority of L. Bowring, Esq., C. S., that in the Jelum district, which includes all the auriferous ground near the Salt Range, with the exception of a small corner near the Indus, in which Mokhud is situated, there were in the year 1850, 158 cradles or troons in use for gold washing, which paid to Government an annual tax of Rs. 525, from Rs. 2 to 5 being levied on each troon. We can obtain no information as to the yield of gold from each troon; but when at Mokhud, in 1848, the Kardar of that place informed me that in—

1844,.........409 tolas* of gold were collected.
1845,.........272...Do. .... Do...... Do.
1846,.........332...Do. .... Do...... Do.

It is of course the object of the gold-washers to conceal, as much as possible, the amount of gold obtained, so as to keep the tax as low as possible.

The Upheaval of the Salt Range, &c.

Before closing our account of the Salt Range, it remains for us to notice certain particulars, in the conditions under which its formations were deposited, and certain phenomena, they, in some places, present, resulting from the general upheaval of the range into its present elevated position.

We conceive that previous to the general elevation of the strata, and during the period of their deposition, they must have undergone a succession of gradual risings and sinkings.

The Salt marl, and the Devonian strata which succeed, have been probably deposited in shallow water, as indicated by the frequent occurrence of ripple markings on the sandstones.

The lower beds of the carboniferous limestone which follow, must, from the abundance of large Brachiopoda they contain, have been deposited at a considerable depth, as such molluscæ are known to characterize a marine zone of upwards of eight hundred feet in depth. At this depth the influence of tides could not produce the ripple markings observed in the Devonian sandstones, and we must therefore infer that, previous to the deposition of the carboniferous strata, the former must have undergone a gradual subsidence to an extent sufficient to admit of the

* This Tola weighs 165 grains. In 1844, there were therefore collected 140 Troy Oz, and 285 grains of gold.

deposition of the latter, the strata of which must have rapidly increased in thickness, so as to have had their surface raised to a depth at which the Cephalopoda, which abound in the upper beds, could exist.

By the deposition of the sandstones and shales of the middle carboniferous series, the strata seem to have been elevated to the surface of the sea, and a beach at least must have existed, on which the marks of falling rain or hail were impressed. After this period, a second subsidence must have occurred to admit of the formation of the upper carboniferous beds, which, in some places, contain Brachiopoda in abundance. By the gradual accumulation of calcareous and sedimentary matter, these seem again to have been brought near the surface, and dry land must have existed at the commencement of the oolitic series on which delicate ferns could support existence.

Succeeding the beds which contain these, we have the oolitic grits and shales, with fragments of large coniferæ which incontrovertibly prove the existence of land, from whence the wood, &c. had been drifted. As we ascend in the oolitic series, the wood becomes scarcer, and as Terebratulæ occur in the upper limestones, and belemnites and ammonites in the upper shales, and green sandstone, it seems probable that soon after the commencement of the formation, a third subsidence occurred, by which the strata were sunk to a considerable depth under the sea, from which they did not emerge until towards the close of the nummulite limestone formation. By a gradual and local deposition of calcareous matter along a particular line, similar to the manner in which coral reefs are formed, a sea barrier may have been raised, inside which, in an inland fresh-water sea, the miocene strata have probably been deposited.

The occurrence of small, water-worn, boulders of nummulite limestone, cemented by calcareous sand, into a conglomerate,

which forms the lower member of the miocene beds in the Salt Range, indicates the existence of a beach where they may have been formed by the lashing of the waves.

As all the strata seen in the Salt Range repose comformably on each other, it appears to us certain, that, from a position of comparative horizontality, they have all been upheaved, subsequent to the deposition of the miocene strata. The upheaving force seems to have extended from east to west, the direction of the Range corresponding to the strike of the strata. Whether this has been exerted by the agency of plutonic or igneous rocks, we have no means of judging, as no rocks of the kind appear in the Salt Range or its neighbourhood.

Between Rhotas and mount Tila the elevating force has raised the miocene strata into an anticlinal ridge. Along the line of this mountain, however, to the westward, it has been exerted with greater violence, having produced a fracture of the strata along the line of strike, elevating the northern portion into a high ridge, the strata forming which have a northerly dip, and present a steep escarpment to the south. Along the south side of this line of fault the miocene strata seem only to have suffered, and are either thrown under the older elevated strata of the escarpment, as along the south side of mount Tila, or tilted up at a high angle with a southerly dip, as at Jelalpoor. Moving westward, the elevatory action seems to have extended, laterally, over a greater surface, and to have produced several lines of fault, which, in the central part of the Salt Range, have in some places thrown the strata into great confusion, and caused the formation of numerous longitudinal valleys, ridges, and transverse ravines. In section No. 8, two very distinct faults, seen in the range west of mount Sikesur, are represented.

At Moosa Khel where the range, running in a north-west direction, is not more than three miles broad, and is intersected

by a transverse gorge, an excellent section is exhibited of the strata, from the carboniferous limestone to the miocene beds. Here the upheaving force has raised the carboniferous strata into an anticlinal ridge, and without fracturing them, has produced a graceful curving which is well seen near the entrance to the ravine. Above the carboniferous strata, a fracture has extended through the oolitic and superincumbent rocks, dipping to the N. N. E., and a vast amount of their debris covers the carboniferous limestone as it dips to the S. S. W. under the plain. Between Moosa Khel and the Indus, where the range again expands, and is eight or nine miles in breadth, considerable disturbance prevails among the strata.

When describing the position of the Kalabag coal, we alluded to the overturning of the strata in the Kalabag hill, and need not refer to it again.

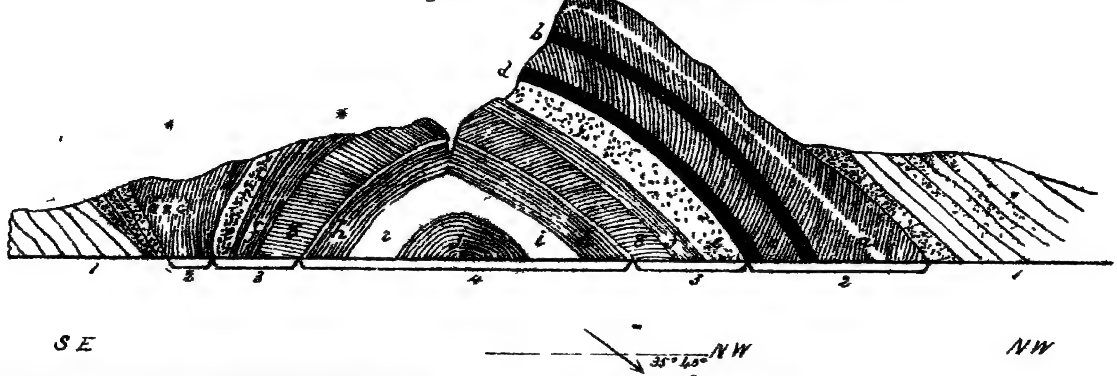
In the Chichalee Range, which runs from north-east to south-west, the elevatory action seems to have extended, laterally, with violence, over but a small extent, but has produced a most remarkable and distinct overturning of the strata along its south-east or scarped side. This is represented in section 9, as seen in the Chichalee Pass, at the entrance to which, in an overturned position, the strata from the miocene sandstones, &c. to the oolities, may be observed, and separated by a fault from the same beds on a steep escarpment, in regular order, dipping to the north at an angle of from 30° to 35° A more complete overturn of strata can nowhere be found. The lower portion has evidently been broken off the upper portion of the series, and by the eruptive force, been made to describe an arc of 180°.'

On moving south along the range, and about five miles beyond the Chichalee Pass, in a ravine called Peela Wan, the strata present a distinct anticlinal axis along the foot of the escarpment.

A more complete over-turn of strata, can nowhere be found. The lower portion has evidently been broken off the upper portion of the series and by the eruptive force, been made to describe an arc of 180°

On moving South along the range, and about five miles beyond the Chinchalee pass, in a ravine called Peelah Wan the strata present a distinct anticlinal axis, along the foot of the escarpment

Section across the Chinchalee range in the Peelah Wan five miles below Kothee.



1.—Miocene sandstones, grits, conglomerates and clays.
2.—Eocene strata.
 a Upper nummulite limestone with flints.
 b. Upper alum shales.
 c. Lower nummulite limestone.
 d Lower alum shales.
3 —Oolitic strata.
 e. Belemnite and ammonite sandstones and shales.
 f Cherty limestone.
6. Sandstones, grits, and shales with fossil wood.

4.—Carboniferous strata.
 h Upper limestone with Encrinites, Productæ, &c.
 i. Sandstone and shales.
 j Lower limestone with Encrinites, Productæ, Orthoceratites, &c
3 —Oolitic strata reversed
2.—Eocene limestone strata reversed and much compressd and shattered, no shales seen
1.—Miocene sandstones reversed

Here a section is exposed of all the strata, from the lower carboniferous to the miocene beds, as in the rough sketch annexed, a fracture extending through all the upper strata and into the upper carboniferous formation, the middle and lower beds of which are only sharply curved by the elevatory action, which has, along the line of fracture, not only separated the southern from the northern portion of the oolitic and superior strata, but has produced a complete overturn of the miocene and eocene beds, bringing them under the oolitic and carboniferous formations. The eocene formation seems to have suffered much during the overturn, as it is much reduced in thickness, and is everywhere shivered and contorted. The alum shales too, seem to have been squeezed out of the limestone as it were, as no trace of them is to be seen.

The same anticlinal arrangement of the strata may be traced along the Chichalee Range, to Mitha near the Kurum river, where a scarped ridge of miocene strata forms the range. All along the southern side of the line of fault or fracture in the Salt Range, the strata have suffered denudation to such an extent as to have removed, in most places, all traces of rock in situ.

The effects of the overturning of the strata in the Chichalee Range, are, to a Geologist, often, most perplexing, and until we had seen the section as exposed in the Chichalee Pass and to the south, we had difficulty in explaining how shales, full of ammonites, belemnites, &c., could possibly occur, dipping apparently under carboniferous limestone full of palæozoic fossil, as may be seen above the village of Kalo Khel near Kalabag.

The upheaval of the Himálayas after the tertiary era, and contemporaneously with the Salt Range, will fully explain the anomalies described by Captain Strachey, of tertiary, secondary, and palæozoic strata dipping on the south or Indian side of the

Himálayas, as it were under the metamorphic schists of the central ridge, while on the northern side they rest upon these in a regular order.

The researches of Dr. Thomson, while engaged on the Thibet Mission, will, we trust, throw light on this interesting subject. A journal of his travels, for two years, in the northern Himálayas is now, we are happy to know, in course of publication, in England.

On the Korana hills.

From the central district of the Salt Range, and apparently running parallel to it, an isolated barren range of hills, called Korana, is seen rising out of the plain of the Jech Doab, or district between the rivers Jelum and Chenab.

The highest point of this range is about forty-six miles S. S. W of Pind Dadun Khan, and about twenty-four miles south-east of the civil station of Shapoor.

When in the Salt Range, near the latter place, in the month of January, I took the opportunity of paying a flying visit to Korana, which, from the abrupt way in which, at a distance, it appears to rise out of the level alluvial plain, I supposed might turn out to be of volcanic origin, and might assist us in arriving at a conclusion, as to the agency by which the strata of the Salt Range were elevated into their present position.

From the Jelum to Korana, is one uninterrupted alluvial plain called the "Bar," about six hundred feet above the level of the sea, thickly covered with a jungle of caper, peloo and mudar, through which, from Shapoor, a four hours' ride brings one to

the foot of the hills. In this district there are but few villages, and the scanty population consists, chiefly, of thieving Beloochees, who, with their flocks of camels, bullocks and buffaloes, wander about the Bar, remaining in any one place, only as long as food and water are procurable. For the latter, they are chiefly dependant on rain which is collected in holes or tanks dug out of the alluvial soil.

Two wells have been dug in the interior of the Bar, on account of the great depth at which water is reached and its generally saline character.

The aspect of a range of hills which Korana, from a distance, presents, gradually disappears as we approach it, and we were not a little surprised to find that it consisted of a succession of isolated ridges of stratified rocks of various sizes running parallel to each other, and rising abruptly out of the plain, studding this over a space of some six or eight miles, and extending towards the Chenab in the neighbourhood of Chineout.

As we could only devote one day to the examination of these most singular rocks, our attention was devoted entirely to a portion of the principal ridge to which all the other smaller ones are apparently similar.

The Korana hill, on the summit of which is the residence of a highly-venerated Fakeer, consists of a ridge of rock stretching from north-east to south-west, and about two miles in length. By the Thermometer, its height is estimated at nine hundred and fifty-seven feet above the plain, at its base. It presents a steep slope to the north-west, on which a few stunted Phoolaee bushes have taken root, and an escarpment to the south-east. It has a peculiarly black volcanic appearance.

The ridge is entirely formed of a coarse brown ferruginous quartzose sandstone, alternating with beds of a greenish quartzite,

which, in many places, passes into a siliceous clay slate. These beds are all distinctly stratified and dip to the north-west at an angle of from 40° to 45°.

The sandstone is traversed by numerous veins of white quartz containing masses of rich hæmatite iron ore, which do not seem to have attracted at all the attention of the natives, as a source of iron, although it can be obtained in considerable quantity, and ought to yield from seventy to eighty per cent. of metal.

Filling small cracks in the sandstone of some small specimens, pyrolusite or peroxide of manganese were obtained. This, when powdered and treated with hydrochloric acid, gave out chlorine in abundance, and when fused with borax, in the oxidating flame of the blow-pipe, gave an amethyst-coloured glass. It occurs in thin dentritic laminæ of a steel-grey colour with a strong metallic lustre, and which exhibit a black streak. This valuable mineral was not detected in any of the quartz veins; but as it very generally occurs associated with hæmatite, it is not improbable that it may be found. It is nowhere an abundant mineral, and as it is in great demand for the manufacture of glass and for bleaching purposes, and fetches a high price in the market, it would be of great importance, were a workable lode of it discovered.

No fossils could be detected in any of the strata, which, from their mineral character, we are disposed to reckon as lower Silurian or Cambrian, the lowest of all fossiliferous rocks, and subordinate to the salt formation of the Salt Range.

From the general parallelism of the Korana ridges to the Salt Range, we think it most probable that at one period, the latter had extended, in breadth, across the plain of the Punjab, from which, by disturbing agencies and extensive denudation,

the softer strata have been removed, leaving only the harder and quartzose sandstones of Korana, as monuments of its former extent.

From Korana, eastward to the foot of the Himálayas, at Roopur, we are not aware that a single rock occurs; nay, we believe, that a traveller might search, in vain, even for a pebble in the sun-baked alluvial plain of the Punjab Doab.

As far as we have observed, no out-bursts of plutonic or volcanic rocks occur in connection with the Korana strata, but the injection into, what probably were, rents in the sandstone, of pure quartz veins containing metallic ores, indicates their having probably been subjected to igneous agency. The limited time we had to spare did not permit of a more extended and careful examination of so interesting a formation, barren and uninviting though it appears to the eye of any one but a Geologist.

In conclusion, we may remark that quartz veins penetrating slaty strata similar to those of Korana, have, in almost every part of the world, been found to be the principal source of the richest metallic ores. Gold ore is almost always found in quartz veins penetrating the most ancient fossiliferous and metamorphic strata, but as that metal is invariably found near the surface of its vein-stone, mining gold has never turned out so profitable a speculation, as washing its "dust" from the debris of its vein-stones in the alluvial deposits at the foot of auriferous ranges. We never have heard that gold was ever seen in the alluvium, at the foot of the Korana hills, but the locality is one where we should expect to find it.

The metamorphic strata of the western Himálayas towards Kashmeer, where they are so extensively invaded by igneous rocks, are certain to be found, when duly examined, to yield rich

metallic ores. The difficulties attending investigations of the kind in such elevated localities are, however, very great. Hitherto the field may be considered as untrodden.

Approximate heights, above the sea level, of localities in or near the Salt Ranges referred to in the accompanying report, calculated from the boiling point of water.

Locality.	Approximate height. feet.	Remarks.
Mount Tila,	3,277	Puka Tank on Summit.
Gurjak Hill above Jelalpore,	1,882	
Plain at Jelalpaor,	619	A little W. of village.
Plain at Jutana,	619	
Pind Dadun Khan,	608	Plain near Fort.
Top of Kosuk Fort,	2,547	At the Musjeed.
Tober Musjeed,	2,141	
Keurah, Deputy Collector's House,	1.138	Built on Salt Marl.
Choa Leyhun Shah,	1,871	Fakeer's Bagh.
Kuringalee Mount,	3,284	
Kutas,	2,155	Field W. of village.
Dhar Range,	3,130	High Point, 2 miles W. of Dehrialu.
Noorpoor,	2,288	Beside village.
Mount Sikesur,	4,990	Old Temple on Summit.
Oochalee in Souc Valley,	2,404	A little above Salt Lake.
Kutha Moosral,	627	
Nulee,	683	A little below village.
Kheree Hill above Nulee,	3,090	
Chideroo,	660	Below village.
Zamanee Hill above ditto,	2,602	
Moosa Khel,	777	Plain between Town and Salt Range.
Maree on the Indus,	633	
Maree 2nd Observation,	636	
Top of Maree Salt Hill	1,196	An Old Temple.
Summit of Dinghote,	746	
Bahadur Dok village,	4,498	Right bank of Indus above Kafir Kote.
Kafir Kote Range,	1,602	High Point N. of Old Fort.
Mount Drengun,	3,710	Trigl. Survey Station.
Besharut village,	2,884	Below Tank.
Mount Diljuba,	2,872	Trigl. Survey Station.
Jelum Station,	671	
Summit of Korana,	1,565	Near Monastery.

The thermometers used in obtaining the above results are made by Newman, and furnished from the magazine of Fort William.

It is to be regretted that they were dispatched without their zero error being accurately ascertained, by comparison with an authentic standard thermometer or barometer. They are divided into ½° divisions, which can be read off to ¼° with tolerable accuracy.

Having fixed the height of Pind Dadun Khan, as six hundred and eight feet, by the barometer, we were enabled thus approximatively to determine the amount of error in the thermometers, and to apply it to correct our results.

In this way they come wonderfully near to the heights obtained by barometric observations.

The small liability to accidents and the portable character of the mountain thermometer as well as the ease with which, in almost every situation, an observation can be taken, render it a most invaluable instrument to an Indian traveller.

The tables we have used are, we believe, those of Prinsep, as given in Colonel Jackson's useful book entitled "What to Observe":—

Approximate Heights, above the Sea Level, of Localities in or near the Salt Range, referred to in the accompanying Report, calculated from Barometric Observations.

Date.	Locality.	Hour of Observation.	Barometer unreduced, corrected for capacity and capillary action.	Attached thermometer.	Detached thermometer.	Approximate Height in feet.	Remarks.
Dec. 25th, 1850.	Summit of Mount Tila, ...	1 P. M.	26.806	57	54	3,270.88	The Barometric observations from which these results were calculated, were made by Mr. Purdon, 1st Asstt. previous to my joining the survey.
Jan. 9th, 1851.	Dimdhote, ...	1 P. M.	27.701	60	58	2,351.12	
„ 27th, „	Old Temple summit of Mount Sikesur, ...	2 P. M.	25.080	62	60	5,128.9	
Feb. 20th, „	Kalabag below the Town, ...	2 P. M.	29.380	70	68	641.8	
„ 24th, „	Summit of Kalabag Hill ...	Noon.	27.809	81	74	2,356.68	
„ 28th, „	Kotkee entrance to Chichalee Pass, ...	8 A. M.	28.755	64	64	1,147.59	These results are probably too high, as the Barometric column was unnaturally depressed before a gale.
„	Highest point of Chichalee Range N. E. of Kotkee, ...	1 P. M.	26.50	75	72	3,628.80	
March 3rd, „	Maree on the Indus, ...	7 A. M.	29.383	56	56	609.3	
„	Temple, summit of Maree Salt Hill, ...	8 A. M.	28.841	68	66	1,221.1	
„ 8th, „	Numul N. side of Salt Range,	9 A. M.	28.900	72	74	1,173.75	
„ 9th, „	Dok N. W. flank of Mount Sikesur, ...	11 A. M.	28.179	74	74	1,950.63	
„ 10th, „	Old Temple (Singasun) Mount Sikesur, ...	Noon.	25.104	69	68	5,221.00	When these observations were made, weather was unsettled and cloudy.
„ 15th, „	Moosa Khel Plain N. E. of Town,	9 A. M.	29.233	63	63	706.22	
„ 21st, „	Amb Village, ...	7 A. M.	27.532	60	61	2,233.	
„ 21st, „	Old Temple, summit of Mount Sikesur, ...	Noon.	24.939	62	60	5,136.9	

Table of Approximate Heights calculated from Barometric Observations.—(Continued.)

Date.	Locality.	Hour of Observation.	Barometer unreduced, corrected for capicity and capillary action.	Attached thermometer.	Detached thermometer.	Approximate Height in feet.	Remarks.
Nov. 14th, 1851	Jelum, Cabin of "Conqueror" Steamer, ...	10 A. M.	29.368	60	60	684.5	For this and the following Barometric observations I am indebted to the kindness of Lt. Grounds of the Indian Navy, who was engaged last cold season in a survey of the River Jelum. His Barometer was a perfectly new Newman's Partent Mountain Barometer in excellent order, and was suspended in the Cabin of the "Conqueror" River Steamer, about 6 feet above the level of the water in the Jelum.
„ 7th to 16th „	Ditto ditto (mean of 10 observations), ...	10 A. M.	29.370	63	63	671.2	
Dec. 25th, „	Pind Dadun Khan "Conqueror" Steamer, ...	10 A. M.	29.519	60	60	616.11	
„ 19th to 25th, „ „ 27th to 31st, „	Ditto ditto mean of 12 observations,)	10 A. M.	29.514	59	59	607.9	
Jan. 21st, 1852.	Shapoor "Conqueror" Steamer (mean of 4 observations)	7 A. M. to 2 P. M.	29.576	55	54	514.02	
„ „	Shapoor, ditto ditto,	9 30 A. M.	29.576	50	50	Height of Korana above the river Jelum at Shapoor.	This observation on Korana was taken from an Aneroid, which had been previously compared with Lt. Grounds' Newman's Barometer.
„ „	Summit of Korana Hill, ...	9 30 A. M.	28.620	54	54		This observation was made on Aneroid, and was subsequently corrected to Barometer.
„ „	Ditto ditto ditto, ...	9 30 A. M.	28.620	54	54	911.15	
„ „	Plain at Base of Korana (mean of 2 observations), ...	7 A. M. 11 30 A. M.	29.370	52	52	1,469.4 Height of Korana above plain at its base.	
„ „	Summit of Korana, ...	9 30 A. M.	28,530	54	54	803.94	These observations were made on Lt. Grounds' Aneroid.

In calculating the heights, I have used for sea-level observations those recorded in the Sûrveyor General's Office, Calcutta, as published in the Journal of the Asiatic Society. Provided with one instrument, this was the only course I could adopt. Galbraith's Barometric Tables, which are considered to be very accurate, were employed, and their extreme simplicity is a strong recommendation in their favour.

The instrument employed was a Newman's mountain barometer, of the latest and most approved construction, furnished from the Arsenal of Fort William. It was safely conveyed from Calcutta to Lahor, in November 1850, attached to a Palkee, and from thence was brought on to Maree on the Indus, by Mr Purdon, from whom I received it in the middle of February 1851. There was then but little leakage, and its indications seemed accurate, until towards the end of March, when it commenced to leak very much and became quite untrustworthy. On examining into the source of the leakage, I found it proceeded partly from a crack which had formed in the upper wooden part of the cistern, and partly from the side of the tube where it passed into the cistern; several plans were tried, without avail, to stop the leakage, and at last the mercury escaped to such an extent, as to admit of air passing into the tube.

By the contact of the escaped mercury with the solder which connected the vernier to the arm of the rack which moves it up and down the scale, the vernier became detached, an accident which never could happen, if the arm of the rack vernier were made out of one piece of metal. It is somewhat strange that an instrument-maker of Mr. Newman's celebrity, should not have guarded against the possibility of an accident, such as I have recorded.

In manufacturing mountain barometers, for use, in the very dry climate of the north-west Provinces of India, it would be highly desirable that the wooden part of the cistern, of Newman's barometers, should be either entirely dispensed with, or be constructed of some thoroughly-baked dry and tough wood. I very much doubt, however, if any wood will stand without cracking, the influence of the sun and hot dry winds of the Punjab, in March, April, and May.

Another barometer of an old pattern, without even a rack adjustment of the vernier, and set in a round mahogany case, which was received in December 1851, on being taken out of its packing-case, appeared in good order. After standing in its leather-case, for a day, in my tent, its mahogany case warped so much as to bend forward the scale (metal) and impede the movement of the vernier. The first day I had occasion to take this instrument out, though carried with the greatest possible care, it leaked so much as to render the results obtained (in the absence of any instrument for comparison) utterly valueless. It is surprising that such an instrument should have been sent all the way from the Arsenal of Fort William to the Punjab, for survey purposes.

A little more care in the selection, and speed in the transmission of instruments required, would save parties engaged in scientific works in the N. W. Provinces, from much trouble and disappointment.

List of specimens submitted to Government, illustrative of the Geology of the Salt Range, &c. &c.

No.	Name.	Locality.	Remarks.
	Devonian Rocks, &c., ...		
1	Red Gypsum Salt Marl, ...	Pind Dadun Khan,	Contains Carbonate of Mag.
2	Metamorphosed Argillaceous rock with radiating crystals of Tremolite? in patches on the surface of the Marl,..................	Pind Dadun Khan,	
3	Amygdaloidal variety of No. 2 with Geodes of Talc, appears like a metamorphosed sandstone	Noorpoor.	
4	Variety of ditto ditto,................	Pind Dadun Khan.	
5	Geodes of Talc in No. 8,.......	Noorpoor.	
6	Flesh-colored crystalline Gypsum,	Keura Salt Marl.	
7	White Gypsum with Rock crystals,.....................................	Maree Salt Marl.	
8	Ditto with crystals of Iron Pyrites,.....................................	Khond.	
9	Reddish Rock Salt,...................	Pind Dadun Khan.	Most esteemed variety.
10	White Rock Salt, ...	Pind Dadun Khan.	
11	Glass Salt, ...	Kalabag.	
12	Old Red Sandstone above salt Marl,.....................................	Baganwala.	Is hygrometric and Magnesian.
13	Variety of ditto ditto,...............	Jubee.	
14	Grey Argillaceous variety, ...		
15	Greenish Schistose sandstone with carbonaceous markings,.............	Chederoo.	
16	Variety of ditto ditto, ...	Mukrach.	
17	Quartzose grit in No. 15,............	Chederoo.	
18	Dolomitic Band in No. 15, ...		
19	Dolomitic Calcareous sandstone, (lower beds,)	Mount Tila.	
20	Variety of ditto, (Upper beds,) ...	Mount ditto.	
21	White variety of ditto,...............	Baganwala.	
22	Yellow variety of ditto, ...	Chumbul Range.	
23	Upper Red sandstone,..............	Pind Dadun Khan.	Contains Magnesia.
24	Purple shale above 23,...............	Amb.	Contains copper-ore concretions.
25	Quartzose grit with grains of Carb. of copper in beds in purple shales, ...	Mount Sikesur.	
26	Ditto with nodule of copper glance,........................	Dokree.	
27	Copper glance concretions from No. 24, ...	Kutha.	
28	Ditto ditto ditto ditto,...............	Ditto.	
29	Ditto in siliceous sinter, ...	Koofree.	
30	Concretion of sulphate of barytes in purple shales associated with copper, ...	Kutha.	
31	Chert from Salt Marl, ...	Dwoda.	
32	Siliceous sinter with Agate, ...		
	Carboniferous Rocks, &c., ...	Choos Salt Marl.	
33	Calcareous sandstone, ...	Kafir Kote.	Contains Producti &c.
34	Grey Limestone, ...	Noorpoor.	Contains Encrinite,s Terebratulæ, &c.

No.	Name.	Locality.	Remarks.
	Black Limestone, ...	Moosa Khel.	Abounds in Orthis, Producti, &c.
36	Flesh-coloured Limestone, ...	Kafir Kote.	Abounds in Encrinites and Palæozoic fossils
37	Tubipoor Limestone masses in No. 36, ...	Chederoo.	
38	Slaty Limestone, ...	Kafir Kote, &c.,	Contain, Orthoceratites, Cratitis Icthyolites, &c.
39	Grey Schistose sandstone above 38, ...	Moosa Khel.	Is Magnesian, fossils scarce.
40	Dark Argillaceous sandstone, ...	Kafir Kote.	
41	Yellow Calcareous bed in ditto,...	Ditto.	Contains Encrinites.
42	Rain-drop-marked sandstone above 39, ...	Moosa Khel,	
43	Magnesian sandstone above 42,..	Ditto,	
44	Fine-grained Magnesian sandstone, ...	Ditto.	
45	Upper Magnesian Limestone, ..	Ditto.	
46	Ditto ditto ditto, ...	Chichalee Range.	
47	Yellow lithographic Limestone below No. 44, ...	Moosa Khel.	Contains a few indistinct Icthyolites.
48	Bituminous sandstone above No. 40, resting on decomposing Bituminous shales, ...	Kafir Kote.	Yields petroleum.
49	Encrinital. Limestone, same as	Nulee.	Contains Oothoceratites, Producti, &c.
50	Brecciated productus Limestone, *Oolitic Secondary Rocks*, ...	Chichalee Range.	Contains Magnesia
51	Yellow Argillaceous sandstone,... No. 46,	Moosa Khel	Contains impressions of ferns, &c.
52	Siliceous Quartzose grit, ...	Chichaleo Range.	Contains pieces of carbonized fossil-wood.
53	Shell Limestone, ...	Muloo Khel, Chichalee Range.	
54	Clay Iron-stone from Shales, alternating with beds of 52, ...	Mulo Khel.	
55	Brown Calcareous grit; the grits having a metallic lustre, are probably the debris of Hyperstheue Rock, ...	Chichalee Pass.	
56	Grey Cherty Limestone, ...	Mulo Khel.	
57	Variety of ditto, ...	Chichalee Pass.	
58	Green Belemnite sandstone, ...	Kalabag.	
59	Upper Quartzose grit, ...	Mulo Khel.	
60	White lower quartzose grit, ...	Chichaleo Pass,	Contains bits of carbonized wood converted into coke.
61	Fossil wood converted into Jet (Kalabag coal) from shales alternating with No. 52, ...	Kalabag.	Has been used as a fuel in the Indus Steamer.
62	Cherty Limestone from a mass resting on salt Marl, ...	Ditto.	Contains Magnesia in small quantity.
63	Ferruginous claystone (burnt bituminous shale,) ...	Moosa Khel.	In beds alternating with Nos. 51 & 52.
	Tertiary Eocene Rocks.		
64	Claystone (burnt shale) forms the base of the formation, ...	Jutana.	Sometimes highly ferruginous.

No.	Name.	Locality.	Remarks.
65	Quartzose grit in contact with 64, ..	Baganwala	
66	Calcareous sandstone beneath alum shales,..........................	Dimdhote near Pind Dadun Khan	Highly fossiliferous, between Kutha and Moosa Khel.
67	Lignite alum shales	Chichalee Pass.	Used in the manufacture of Alum.
68	Yellow Marly Limestone above shales, ...	Baganwala.	Contains nummulites, ostreæ, &c.
69	Nummulite Limestone above 68,	North side of Mount Tila.	
70	Lower Nummulite Limestone,......	Bukh Ravine, Moosa Khel.	Fœtid when bruised,
71	Chalky lower N. Limestone,....... .	Kutha.	
72	Lower Nummulite Limestone with Fasciolites, ...	Koofree.	
73	Argillaceous Numl. Limestone, ...	Mulo Khel.	Fœtid when bruised. contains black flints.
74	Upper Nummulite Limestone,......	T o b e r above Pind Dadun Khan.	Full of flints.
75	N. Limestone with nummulites,...	Kalabag Hill.	
76	Black Flint from 73 and 74, ...	Bukh Ravine, Moosa Khel.	
77	Lignite (coal,)	Baganwala.	
78	Lignite (coal) from same seam about a mile distant from locality of 77,............................	Ditto.	Contains 1.840 Ash per cent.
79	Lignite, ...	N. side of Mount Drengun.	Much weathered, very brittle.
80	Ditto, ...	Pid near Pind Dadun Khan.	Ditto ditto ditto.
81	Ditto, ...	Dundhote 2 miles W of last locality.	Ditto ditto ditto.
82	Ditto, ...	Nilawan ravine below Noorpoor.	Ditto ditto ditto.
83	Ditto (coal,)	Kurumee ravine near Kutha.	
84	Ditto ditto, ...	Chichalee Pass.	Contains 30 per cent. of Ash.
85	Porous Gypsum, associated with sulphur,..................................,	Jaba 10 miles E. of Kalibag.	Produced by the decomposition of limestone.
86	Native sulphur in Limestone passing into Gypsum,...............	Jaba ditto ditto.	
86	Sulphur prepared by sublimation from Tertiary Miocene Rocks,...	Ditto.	
87	Petroleum, ...	Ditto.	Floats on the surface of water.
88	Grey Calcareous sandstone, ...	Kulur Kuhar.	Yields gold dust, contains fossil bones, &c.
89	Grey hard Calcareous sandstone in beds alternating with No. 88	D h a r Range near Dehrialah.	
90	Argillaceous Grit, ...,	Ditto.	Used as a millstone, contains fossil bones, &c.
91	Jet (fossil wood) in masses in No. 88, ...	Narwa near Kulur Kuhar.	
92	Black washed Iron sand with, gold dust. the Debris of No. 88....., ...	Bed of Boona Nula.	Ready for amalgamation process.

No.	Name.	Locality.	Remarks.
93	Red indurated clay alternating with 88, 89 and 90, ...	Kulur Kuhar.	
	Alluvial Rocks.		
94	Calcareous Tufa, ...	Mount Diljuba.	Extensively burnt for lime.
95	Kunkur, ...	Jelum.	Used extensively as a road metal.
	Lower Silurian or Cambrian Rocks?	Korana • Hiles Jotch Doab.	
96	Ferruginous quartrzose sandstone,	Korana.	
97	Quartzite in beds in ditto, ...	Ditto.	
98	Siliceous clay slate in beds alternating with 96 and 97, ...	Ditto.	
99	Hæmatite in Quartz veins in No. 96, ...	Ditto.	Is a rich ore of Iron.
100	Peroxide of Manganese filling fissures in No. 96, ...	Ditto.	

Description of Sections.

TABLE NO. I.

Index to Table of Colours and Markings used in Section of Salt Range.

O.—Alluvium.

1.—Tertiary Miocene Rocks.

a. Greenish sandstones, argillaceous grits, conglomerates and red and green clays.

2.—Tertiary Eocene Rocks.

b. Nummulite limestone.

c. Brown calcareous sandstone.

d. Alum Shales with Lignite.

3.—Secondary Oolitic Rocks.

e. Cherty thin-bedded limestones with shales.

é. Yellow, iron-stained quartzose sandstones, grits and bituminous shales.

è. Green belemnite sandstone and shales.

4.—Primary Carboniferous Rocks.

f. Upper limestone, sometimes Magnesian.

g. Grey sandstone and shales.

h. Lower limestone, calcareous sandstones and shales.

5.—Primary Devonian Rocks.

i. Upper red variegated sandstones, grits, conglomerates and clays.

j. Grey Dolomitic (Magnesian) sandstone.

j. Greenish micaceous sandstones and shales.

k. Lower red sandstone and grit with conglomerates.

6.—Devonian salt marl.

l. Red marl with gypsum and rock salt.

7.—Lower Silurian or Cambrian Rocks.

In the Geological Maps, Nos. 5 and 6 have been represented by one colour.

N. B.—Same scale has been used for heights and distances.

TABLE No. II.

Section showing the supposed vertical thickness of the various formations seen in the Salt Range, estimated at points where they attain a mean development.

TABLE No. III.

This Section represents the Tertiary Miocene formation as seen in the Rhotas gorge, between the plain near Jelum and the village of Rhotas, and to the N. of this, towards Bukrala, on the line of the Peshawur road.

On entering the gorge, through which the Kuhan stream ows towards ythe Jelum, beds of soft gre snadstone, red clays

and conglomerates are seen dipping under the plain in a S. E. direction, at an angle of from 75° to 80°. A succession of these beds follow, the angle of their dip gradually diminishing, until about a mile from the entrance of the gorge, where they present a beautiful anticlinal curve. Beyond this, their dip again increases, and at Rhotas is 75° to the N. W.

Crossing the bed of the Kuhan Nula, and proceeding along the Peshawur road, beds of alluvium are seen for about a mile. Beyond this, the sandstone strata again appear, dipping at an angle of 75° to the S. E., and may be traced almost uninterruptedly, at Rawul Pindee, presenting a succession of anticlinal and synclinal axes stretching from N. E. to S. W.

TABLE Nō. IV.

Section across the Rhotas range at Mount Tila between the villages of Hoon and Bhet, at right angles to the strike of the strata.

On ascending the hill from Hoon we have—

1.—A succession of Tertiary miocene strata containing numerous mammalian bones, Saurian teeth, &c. Near Hoon they dip to the S. S. E. at an angle of 70°, but on ascending the hill, they present an anticlinal axis, beyond which they dip to the N. N. W., as if under the escarpment of Tila, an appearance which is evidently produced by a fault.

2.—Salt Marl with Gypsum. This is very indistinctly seen at the base of the escarpment.

3.—Red Sandstone with bands of Conglomerate.

4.—Grey Dolomitic (Magnesian) Sandstone, brecciated in some places.

5.—Greenish micaceous Sandstones and Shales from the decomposition of pyrites, apparently in some of the beds of shale; they have been converted into a red clay-stone.

6.—Red Clays and Schistose micaceous sandstones.

7.—Marly yellow nummulite limestone with Ostreæ; in some places is a mass of these shells.

8.—Tertiary miocene strata similar to No. 1.

Table No. V.

Section across the Salt Range near Baganwala.

In an ascending order we have—

1.—An extensive alluvial deposit of boulders of gravel, sand and clay.

2.—Salt marl. This does not appear on the surface, but from the abundance of saline efflorescence, evidently occurs beneath.

3.—Red sandstone with bands of conglomerate; its lower beds are schistose and argillaceous, contain laminæ of gypsum, and are encrusted with a saline efflorescence.

4.—Greenish micaceous Sandstones and Shales.

5.—Grey Dolomitic (Magnesian) Sandstone.

6.—Upper red variegated Sandstones, grits, conglomerates and red shales.

7.—Yellow, marly nummulite Limestone, reposing on bituminous shales, indicated by the dark line in which a bed of lignite, from 3 to 5 feet thick, occurs.

8.—Miocene tertiary Sandstones, argillaceous Grits, Conglomerates and red indurated Clays containing mammalian bones and teeth, and lumps of brown silicified wood.

The above strata all dip to the N. N. W. at an angle of from 45° to 50°.

TABLE NO. VI.

Section across the Salt Range from Keura towards Chooa Seydun Shah.

1.—Alluvium.

2.—Red marl with beds and masses of gypsum and salt, the strata of the former being often bent, and contorted in a most remarkable manner. The marl has been much disturbed, and presents few or no indications of its being a stratified deposit, except towards its upper surface, where it dips under the superior rocks.

3.—Lower red sandstone with grit and conglomerates.

4.—Greenish micaceous sandstones and shales.

5.—Grey Dolomitic (Magnesian) Sandstone, weathering of a fawn colour.

6.—Upper red variegated Sandstones, Grits, Conglomerates and clays.

7.—Brown calcareous Sandstone (Eocene).

8.—Eocene bituminous Alum Shales in which is a bed of inferior lignite.

9.—Nummulite Limestone with irregular-shaped masses of grey flint.

10.—Patches of miocene tertiary Sandstones, rapidly disintegrating; contain mammalian bones, &c.

Table No. VII.

Section across the Nilawan Ravine in the Salt Range below Noorpoor,* as seen about three miles from the plains.

1.—Red Marl, presenting in its upper part, thin alternating beds of red and purple clay, impure rock salt and gypsum; below it exhibits the usual disturbed appearance, and contains large masses of salt and gypsum.

2.—Lowerred Sandstone, Grits and conglomerate bands.

3.—Greenish micaceousSandstones and Shales, with indistinct carbonaceous markings.

4.—Grey Dolomitic (Magnesian) Sandstone, weathering of a dark brown colour.

5.—Upper red Sandstone, Grits, purple and red Shales and Clays.

6.—Primary carboniferous limestone, containing Encrinites, Producti, Spiriferæ and Terebratulæ.

7.—Eocene brown calcareous Sandstone resting on a thin bed of ferruginous claystone.

8.—Alum Shales with lignite seam, much decomposed in ts out crop.

9.—Nummulite Limestone with Flint.

10.—Tertiary miocene Sandstones, Grits, Conglomerates, &c., containing fossil bones and masses of silicified wood.

The above strata dip from either side of an anticlinal axis at an angle of 35°.

Table No. VIII.

Section across the Salt Range from the Zamanec Wan Ravine E. of Chederoo to the neighbourhood of Dok. The distance is almost 7 miles, and the general dip of the strata is to the N. E. at an angle varying from 45° to 55°.

In this Section the heights and distances are considerably falsified.

1.—Salt Marl with Gypsum.

2.—Lower red Sandstone, Grits and Conglomerates.

3.—Greenish micaceous Sandstones and Shales with thin bands of hard Dolomitic Sandstone of a steel grey colour.

4.—Dark red variegated schistose Sandstone, Grits and beds of Conglomerate, succeeded by Shales of a chocolate and purple colour, containing copper ore nodules.

5.—Lower primary carboniferous Limestone and calcareous Sandstone, abounding in Encrinites, Producti, Spiriferæ, Orthoceratites, and Ceratites, &c.

6.—Middle grey Sandstones and Shales.

7.—Upper primary carboniferous Limestone, full of Encrinites, Producti, &c.

N. B.—In the Bukh Ravine, 8 miles W. of line of section, this limestone is magnesian, and appears to contain no fossils.

8.—Secondary, oölitic, yellow, iron-stained quartzose Sandstones, Grits and bituminous Shales, containing masses of carbonized wood.

9.—Oolitic, cherty thin-bedded Limestones with a few shales.

10.—Lower tertiary eocene Alum Shales resting on a coarse and highly fossiliferous limestone, containing Nummulites and large gasteropodous mollusca.

11.—Lower nummulite Limestone ; its lower beds an imperfect conglomerate.

12.—Upper Alum Shales and blue Marl.

13.—Upper nummulite Limestone ; lower beds, argillaceous, upper compact nodules, and irregular-shaped masses of black flint abundant.

14.—Tertiary Miocene Sandstones, Grits, Conglomerates and red Clays, containing mammalian bones, &c.

a. *a.*—Are faults.

TABLE No. IX.

Section across the Chichalee Range on the W. bank of the Indus, as seen on the W. side of the Chichalee Pass.

1.—Primary carboniferous strata. These do not appear on the surface along the line of section, but occur in the position represented in ravines, both E. and W. of the Pass.

2.—Oolitic, yellow, iron-stained quartzose Sandstones, Grits and bituminous Shales.

3.—Oolitic, cherty and shell limestones, alternating with bituminous shales. The upper limestone beds contain Terebratulæ, Belemnites, fragments of Echinidæ, &c.

4.—Black Shales passing into a green ferruginous sand stone. These beds contain Belemnites, Ammonites, Gryphea and Saurian teeth, bones, &c., associated with fragments of carbonized wood.

5.—Iron-stained quartzose Sandstone, with fragments of jet.

6.—Lower Eocene Alum Shales, containing irregular beds or seats of lignite.

7.—Lower Nummulite Limestone, its lower beds are imperfect Conglomerates.

8.—Upper Alum Shales.

9.—Upper Nummulite Limestone with flints.

10.—Tertiary Miocene strata with the usual fossils.

A. A. (*a.*) a fault occurs to the South, of which at the entrance of the Pass, the beds, 3, 4, 5, 6, 7, 8, 9 and 10, are seen in reversed order. The nummulite limestone, and oolitic strata, are much shattered and compressed, the strata of the former being often remarkably contorted.

TABLE NO. X.

Sketch of a slab of carboniferous limestone from Moosa Khel in the Salt Range, containing Orthoceratites and Ceratites.